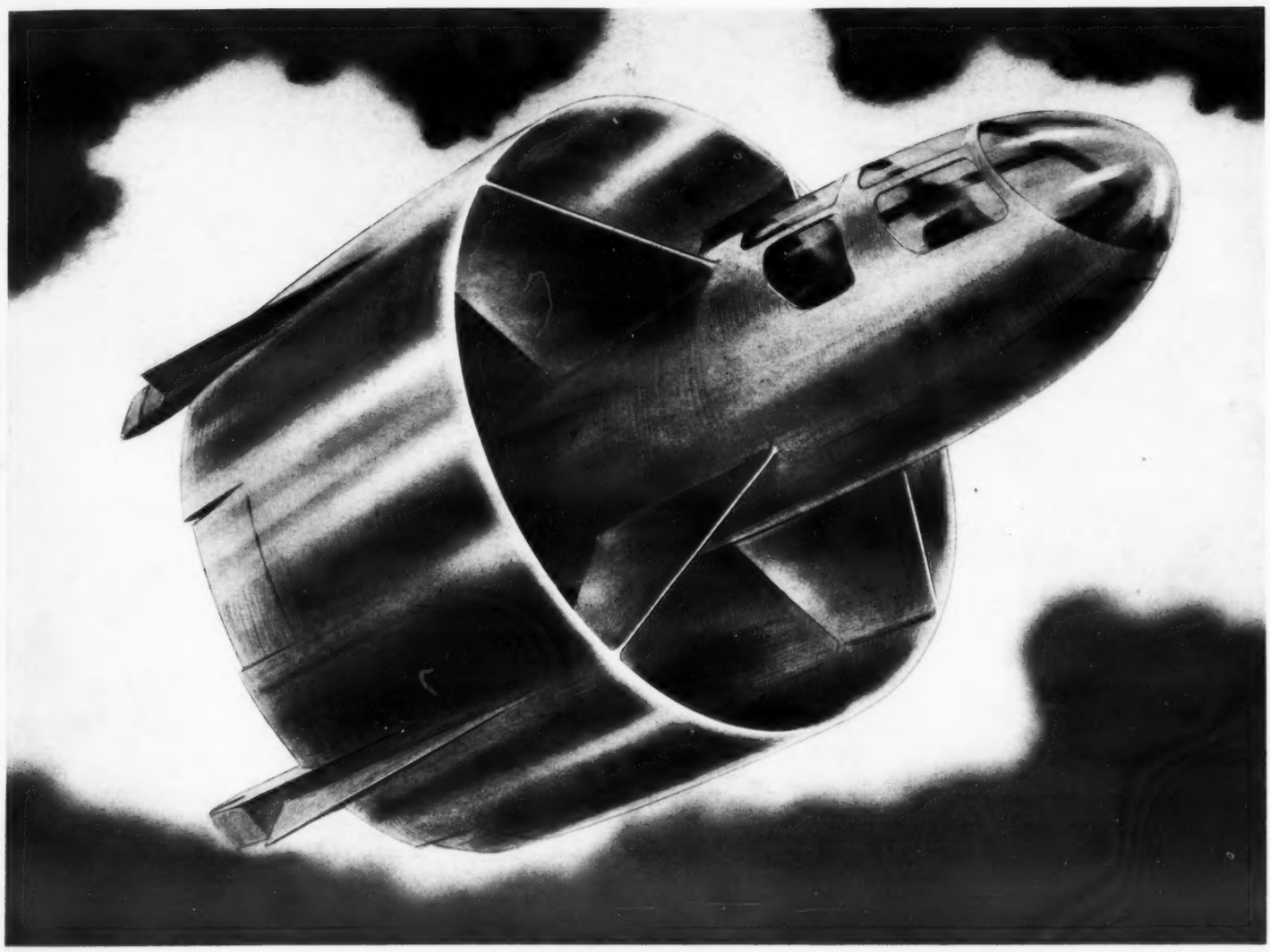
INTERAVIA

REVIEW OF WORLD AVIATION



Price of this issue

U.S.A.:	80 cents
British Isles:	3 s
Switzerland:	Fr. 2.80
Netherlands:	Fl. 2.50
Denmark:	Cr. 5.-
Germany:	DM 2.75
France:	Fr. 250
Italy:	Lire 410

IN THIS ISSUE

The Next Fifty Years

VOLUME X 1 1955

GILFILLAN
GCA

QUADRADAR

RCA International Division,
30 Rockefeller Plaza,
New York 20, N. Y.
Exclusive Distributor
for Export Sales.

GCA RADAR AND ELECTRONICS
Gilfillan
AROUND THE WORLD

World-wide list of RCA International Division Distributors: Inquire of nearest office.

ARGENTINA
RCA VICTOR ARGENTINA, S.A.
Bartolome Mitre 1961, Buenos Aires, Argentina

BELGIUM
SOCIETE BELGE INDUSTRIELLE S.A.
14 Square Marie-Louise, Brussels, Belgium

BRAZIL
RCA VICTOR RADIO, S.A.
Rua Visconde Da Gavea 125, Rio de Janeiro, Brazil

BURMA
JING HONG TRADING CORPORATION
174 Phayre Street, Rangoon, Burma

CHILE
CORPORACION DE RADIO DE CHILE, S.A.
Camino A. Puente Alto 3333, Santiago, Chile

COLOMBIA
TELETEC LIMITED
Carrera 8A, No. 20-00, Bogota, Columbia

CUBA
HUMARA Y LASTRA S. EN D.
Apartado 508, Havana, Cuba

DENMARK
A/S ELECTRONICA
Dampfaergevej 3, Copenhagen, Denmark

FRANCE
RADIO EQUIPMENTS
65 Rue de Richelieu, Paris, France

GERMANY
HENLEY AND COMPANY, INC.
Gross-Nabasstrasse 11, Munich 59, Germany

GREAT BRITAIN
RCA PHOTOPHONE LTD.
36 Woodstock Grove, London W 12, England

HOLLAND
AMROH TECHN. IMPORT/EXPORT EN FABRICAGE
Heerengracht 88, Muiden, Holland

IRAN
FIROOZ TRADING COMPANY
Avenue Saadi, Sabet Tasal Bldg., Teheran, Irán

ITALY
RCA ITALIANA S.p.A.
Via Giulio Caccini No. 1, Rome, Italy

KOREA
KORCAD CORPORATION
P. O. Box 5, Kwang Wha Moon, Seoul, Korea

NORWAY
AKSJESELSKAPET NERA
P. O. Box 4060, Oslo, Norway

PAKISTAN
RCA INTERNATIONAL FIELD OFFICE
Nadir Nouse, McLeod Road, Karachi, Pakistán

PANAMA
PANAMA RADIO CORPORATION
P. O. Box 406, Panama City, Panama

PORTUGAL
INSTITUTO PASTEUR DE LISBOA
R. Nova Do Almada 69, Lisbon, Portugal

PUERTO RICO
SPLENDED, INC.
161 Fernandez Juncos Ave, San Juan, Puerto Rico

SINGAPORE
RCA INTERNATIONAL FIELD OFFICE, 31 Medeiros Building, Cecil Street, Singapore 1, Straits Settlements

SOUTH AFRICA
TELECOMMUNICATIONS AND ELECTRONICS AFRICA LTD., P. O. Box 10523, Johannesburg, South Africa

SPAIN
INDUSTRIA ELECTRONICA, S.A., Avenida De America y Hernandez De Tejada, Madrid, Spain

SWITZERLAND
JACQUES BAERLOCHER, Haus Talgarten, Nuschelerstrasse 31, Zurich 1/39, Switzerland

TURKEY
TEKNIKA T.A.S.
Galata 153, Istanbul, Turkey

URUGUAY
CIA RADIOELECTRICA URUGUAYA, LTD.
Guana 2226, Montevideo, Uruguay

VENEZUELA
INTELEC S.A., EDIFICIO INDUSTRIA
Ave. Este 2, PTE Republica, Caracas, Venezuela

COMPANIA ANONIMA ALMACEN AMERICANO
Edificio Phelps, Caracas, Venezuela

INTERAVIA

Review of World Aviation

PUBLISHERS AND DISTRIBUTORS: INTERAVIA S.A., GENEVA 11

Index to Volume X — 1955

The first number after each title refers to the magazine, the second number to the pages

General Subjects

No. 1. The Next Fifty Years
No. 2. "Ice Water Imperialism"
Polar Crossroads
No. 3. Pocket-Size Combat Aircraft
No. 4. Debit and Credit in Air Transport
No. 5. Guided Missiles and Rockets
Soviet Re-Equipment Plans
No. 6. 21st Paris Salon
N.A.T.O. Show...
No. 7. Spaceships, Satellites...
No. 8. Summer Air Shows
Paris — Geneva — Moscow — Toronto
No. 9. After the Geneva Conference
Farnborough
No. 10. Cooperation in Air Transport
No. 11. Atoms for Peace
Ten Years in British Aviation
No. 12. If Peace Did Break Out...
Recent Aerodynamic Advances

Index by Subjects:

Biographical - Historical

"Castles in the Air" at the Turn of the Century : 1, p. 24
Brief History of Polar Flying—Charles Dollfus : 2, p. 110
From the Solar Column to the Universal Time Clock : 2, p. 116
Thirty Years of Celestial Air Navigation—Antoine Bastide: 2, p. 126
Five Years of N.A.T.O. : 3, p. 194
Professor Einstein's "Folly" : 9, p. 684
Silver Jubilee of Air France's South Atlantic Route : 10, p. 758

Air Politics

"Ice Water Imperialism" : 2, p. 87
The West-East No-Mans-Land in Europe : 3, p. 187
Towards a New Air Arms Policy—General Aldo Urbani : 3, p. 195
After the Ratification by the German Parliament : 4, p. 269
Long-Range Missiles will make Peace Unavoidable : 5, p. 310
Situation Report from Bonn : 6, p. 432 ; 8, p. 615 ; 9, p. 707 ; 12, p. 939
After the Geneva Conference : 9, p. 665
President Eisenhower Offers : 9, p. 666
President Eisenhower's Proposal : 9, p. 683
West Germany : From Planning to Execution : 11, p. 858
Talking of Peace... : 12, p. 897
If Peace Did Break Out—A. Huber : 12, p. 899

Air Law

The Revision of the Warsaw Convention—A. Meyer : 11, p. 863

Atomic Energy

Atomic Energy—The Power of the Future : 1, p. 46
Atomic Energy in Search of a Market : 11, p. 847

International Organizations

The European Idea is Gaining Ground (A.I.C.M.A.'s Fifth Annual Meeting in Rome May 20th-21st, 1955) : 7, p. 522
A Decade of the New I.A.T.A. : 10, p. 749
Thoughts on Strasbourg—Dr. L. H. Slotemaker : 10, p. 753
Cooperation—Willem Deswarte : 10, p. 756
I.A.T.A. in New York: 12, p. 923

Aircraft

Commercial Aircraft

Some Reflections on The Comet Inquiry—James Hay Stevens : 4, p. 257
New Aircraft for Short and Medium Stages : 10, p. 764
De Havilland Comet 4 : 10, p. 769
S.N.C.A.S.E. Caravelle : 10, p. 770
Vickers Viscount 800 : 10, p. 774
Lockheed Electra : 10, p. 774
Fokker Friendship : 10, p. 775
Aviation Traders Accountant : 10, p. 777
Hurel-Dubois HD.32/HD.321 : 10, p. 778
Handley Page Herald : 10, p. 779
Convair-Liner 440 : 10, p. 781

Military Aircraft

Fouga CM 170 Magister a Standard N.A.T.O. Trainer : 1, p. 48
P-16 A Swiss Jet-Powered Combat Aircraft : 6, p. 442
The B-52 in the Torture Chamber : 11, p. 856
Double Delta for Draken : 12, p. 932

Rotary-Wing Aircraft

The Helicopter Goes Mountaineering : 8, p. 607
The Future of the Civil Helicopter in Britain—Raoul Hafner : 9, p. 692
Richard's Cyclogyros : 11, p. 864

Power Plants

Two Rôles for One Turbojet—H. Denamur : 3, p. 181
Two-Dimensional Retractable Ramjets—Dipl. Ing. Otto Reder : 3, p. 197
The Engines for Tomorrow's Airliners : 4, p. 252
Jet Production in Canada : 7, p. 524
Two New Civil Propeller Turbines (Allison 501-D10 and Bristol BE 25) : 7, p. 532

Guided Missiles, Rockets and Space Ships

Reaching for the Stars—Prof. Gaetano Arturo Crocco : 1, p. 22
The Last Weapon but One : 5, p. 299
The State of the Art—James Fenton Smith : 5, p. 300
" Hush, It's Top Secret " Britain and Guided Missiles : 5, p. 314
" Nike " : 5, p. 317
Guided Missiles for Home Defence—Colonel (Ret.) H. Aldinger : 5, p. 318
Space Ships, Satellites... : 7, p. 497
Space Flight is Possible : 7, p. 497
The " Mouse " Project—Prof. S. F. Singer : 7, p. 502
On Top of the World : 7, p. 504
Engineering Problems of Manned Space Flight—Krafft A. Ehricke : 7, p. 506
Rocket Research and Production in Italy—General Aldo Urbani : 7, p. 513
Sweden's Guided Missile Programme : 7, p. 514
Rockets and Guided Missiles at the Paris Show : 8, p. 602
British Rockets at the R.A.E.'s Jubilee Exhibition, Farnborough July 1955 : 9, p. 694

Technical and Industrial

V.T.O. Chronicle of a Technical Revolution : 1, p. 27
S.N.E.C.M.A. and Vertical Take-Off—Henri Desbruères : 1, p. 29
The Coleopter—A formula for Economy— Dipl. Ing. Helmut Von Zborowski : 1, p. 29
S.N.E.C.M.A. and the Coleopter—Dr. Ing. Hermann Oestrich : 1, p. 35
The Mechanics of Flow on Annular Wings—Dr. Wilhelm Seibold : 1, p. 51
Structural Principles of the Coleopter Wing—Prof. Dr.-Ing. Heinrich Hertel : 1, p. 53
Design of Lightweight Simplified Combat Aircraft—E. H. Heinemann : 3, p. 172
Interview with W. E. W. Petter : 3, p. 179
Miniaturized Avionics—K. M. Miller : 3, p. 183
" Television Flight " by 1958 ? : 3, p. 184
The Bendix Polar Path Compass System : 3, p. 196
How Impenetrable is the Iron Curtain ? : 5, p. 324
The Aerodynamic Laboratory at Vernon—Chief Engineer P. Carrière : 5, p. 331
Fire Control Systems—Lieutenant-General D. G. H. Brethouwer : 5, p. 333
The French Aircraft Industry in 1955
I. France's Reorganized Industry Pioneers in New Design Fields : 6, p. 382
II. Neck and Neck with Foreign Rivals : 6, p. 387
The " Mouse " Project—Prof. S. F. Singer : 7, p. 502
Engineering Problems of Manned Space Flight—Krafft A. Ehricke : 7, p. 506
N.A.C.A. Investigates " The Heat Barrier " : 7, p. 511
Parachutes are Specialized : 7, p. 515
Jet Production in Canada : 7, p. 524
British Aviation in 1954-55 : 9, p. 686
The U.S. Aircraft Industry Draws its Balance : 9, p. 708
N.A.C.A. Investigates Prevention of Fire and Passenger Safety in Crash Landings : 10, p. 782
Improving Lift by Boundary Layer Control : 12, p. 925
" Wasp-Waisted " Transonic Fighters : 12, p. 928
The Jet Flap : 12, p. 931

Navigation - Radar

Air Navigation in the Arctic : 2, p. 112
Radar Installations at Zurich-Kloten Intercontinental Airport : 2, p. 118
Radar and Television at Orly Airport, Paris—E. Guigonis : 2, p. 120
Thirty Years of Celestial Air Navigation—Antoine Bastide: 2, p. 126
" Television Flight " by 1958 ? : 3, p. 184
The Bendix Polar Path Compass System : 3, p. 196
The Vortac Air Navigation System Controversy—Maurice A. Garbell, D. Sc. : 6, p. 449
British Navaids—Howard B. Capes : 9, p. 701
Trends in British Ground Aeradio Equipment—E. E. Warburg : 9, p. 703
Tacan (British Version) Details Released : 9, p. 705
VHF or UHF ?—J. R. Brinkley : 9, p. 706
The Tacan UHF Radio Navigation System : 10, p. 792
Radar... Electronic Eyes for Air Warning and " Automatic Pursuit " : 12, p. 906
The Gee System of Navigation—P. G. Day & K. W. King : 12, p. 941

Meteorology

Rescue and Supply Work by Air in Greenland—Robert Pommier, 2, p. 107

Ground Organization

Radar Installations at Zurich-Kloten Intercontinental Airport : 2, p. 118
Radar and Television at Orly Airport, Paris—E. Guigonis : 2, p. 120
How Big is Big ? (Idlewild) : 6, p. 429
Fiumicino Intercontinental Airport—Lieutenant Colonel Giuseppe Amici : 7, p. 520

Air Transportation

Long-Range Commercial Transports of the Coming Decade : 1, p. 26
A New Era in Air Transport : 1, p. 42
" Fifty Years On "—Air Transport in A.D. 2005—Peter G. Masefield : 1, p. 44
The Importance of Arctic Flying—Colonel Bernt Balchen : 2, p. 88
By Arild Viking to the New World : 2, p. 90
Is Talk of an Air Transport Crisis Justified ? : 4, p. 235
Air Transport can Avoid a Crisis—Max Hymans : 4, p. 238
A Bright Decade Ahead—If...—Ralph S. Damon : 4, p. 240
Air Travel—1985 : 4, p. 240
Mass Transportation by Air Lies in Aircoach Expansion—Captain Edward Vernon Rickenbacker : 4, p. 242
" Crisis " is Too Strong a Word—Don Cesar Gomez Lucia : 4, p. 244
Commercial Aviation in the Forefront of Progress—Emile Delclaux : 4, p. 246
Air Transport Diagnoses its Ills and Prepares for Tomorrow —Pierre M. Gallois : 4, p. 247
Back to Luxury : 4, p. 255
The Next Generations of Long Range Aircraft : 4, p. 267
The Rocket-Driven Commercial Airliner—Dr. Walter R. Dornberger : 5, p. 320
Hallo, Elysées 20-60—Air France's New Management : 6, p. 447
The Air Transport Association's " Facts and Figures "for 1954 : 7, p. 529
Thoughts on Strasbourg—Dr. L. H. Slotemaker : 10, p. 753
Cooperation—Willem Deswarte : 10, p. 756
Turbine Air Transportation One Step over the Threshold—Maurice A. Garbell : 10, p. 759
New Aircraft for Short and Medium Stages : 10, p. 764
Long-Range Air Transport in an Undivided World : 12, p. 908
Long-Range Aircraft for Tomorrow's Air Transport : 12, p. 911
Eastern European Air Transport before the Camera : 12, p. 917
Deutsche Lufthansa over the Atlantic : 12, p. 919

Service Aviation

The Air Arm of the Future : 1, p. 39
Mounting Guard at the Pole : 2, p. 98
From Short-Life to Pocket-Size Aircraft : 3, p. 163
One Idea, One Programme : Four Countries : 3, p. 164
Programmes and Projects for Pocket-Size Combat Aircraft : 3, p. 168
The Miniaturization of Aircraft—Edmond de la Gabbe : 3, p. 170
" CONAD " : 4, p. 260
An American Antidote to Enemy Atom Bombers : 5, p. 330
Communist China's Air Build-Up : 6, p. 431
A New Lease of Life for the Piloted Fighter ? : 8, p. 585
N.A.T.O. Exercise " Carte Blanche " : 8, p. 614
SAC-CONAD-BALMI : 9, p. 670
New Russian Designs : 9, p. 680
A School for " Electronic Artillerymen " : 9, p. 699

Naval Aviation

Let's Land On : 4, p. 262
Sub Helps Flying-Boat : 6, p. 436
The U.S. Navy's " Flying Platforms " : 7, p. 517

Exhibitions and Congresses

21st Paris Salon :

How to Sell N.A.T.O. ? : 6, p. 381
Britain's Participation in The Paris Salon 1955 : 6, p. 409
Italy at the 21st Paris Show : 6, p. 417
The Netherlands' Contribution : 6, p. 421
Belgian Participants : 6, p. 422
America's Exhibitors at Paris : 6, p. 423
Le Bourget—June 19th, 1955 : 8, p. 574
A New Lease of Life for the Piloted Fighter ? : 8, p. 585
Model Gallery at Le Bourget : 8, p. 590
Le Bourget—The Engines Salon : 8, p. 592
The Equipment Industry in Paris : 8, p. 594
Rockets and Guided Missiles at the Paris Show : 8, p. 602

Farnborough :

First Impressions of the 16th S.B.A.C. Display, Farnborough : 10, p. 787
Ten Years Preparation for Twenty Years of Flying : 11, p. 825
The British Aircraft Industry's Post-War Exports : 11, p. 832
Farnborough in Pictures : 11, p. 834
Snapshots of the Engine Display : 11, p. 839
Safety Equipment, Airframe and Engine Accessories : 11, p. 840
Target Aircraft, Guns, Rockets : 11, p. 845
Aviation Electronics : 11, p. 846

First European Aeronautical Congress Paris December 14th-18th, 1954 : 2, p. 123
" ILSY 5 " : 7, p. 528
What Use are Air Shows ? : 8, p. 573
Geneva International Air Circus : 8, p. 603
Tushino 1955... : 8, p. 606
Canadian International Air Show : 8, p. 613
British Rockets at the R.A.E.'s Jubilee Exhibition, Farnborough July 1955 : 9, p. 694
Preview of the 1955 Turin Show : 9, p. 695
U.S. National Aircraft Show 1955 : 11, p. 860
Air Display at Munich/Oberwiesenfeld : 11, p. 859

Aviation Finance

The Trend Towards Diversification of Production : 3, p. 189
Air Transport Diagnoses its Ills and Prepares for Tomorrow —Pierre M. Gallois : 4, p. 247
End of a Honeymoon ? : 4, p. 261
The Air Transport Association's " Facts and Figures " for 1954 : 7, p. 529

Miscellaneous and Humorous

The Next Fifty Years : 1, p. 19
Introductory Remarks—Theodore Von Karman : 1, p. 20
The Air Hostess Told Us : 1, p. 47 ; 4, p. 243 ; 7, p. 512 and p. 516 ; 8, p. 589
A Nineteenth Century Prophet—Alfred Heerhartz : 4, p. 256
The Story of Air Express in the United States : 11, p. 853

Progress in Pictures

4, p. 264

Equipment Round-up

2, p. 124 ; 3, p. 199 ; 4, p. 270 ; 6, p. 444 ; 8, p. 594 ; 10, p. 790 ; 11, p. 840

Book Reviews

1, p. 55; 2, p. 128; 3, p. 200; 5, p. 337; 6, p. 448; 7, p. 534; 9, p. 710 ; 11, p. 864 ; 12, p. 943

The Mind of Mr. Reader

2, p. 130 ; 6, p. 446 ; 11, p. 866 ; 12, p. 944

What's in the Air ?

1, p. 56 ; 2, p. 121 ; 3, p. 192 ; 4, p. 265 ; 5, p. 335 ; 6 p. 433 ; 7, p. 526 ; 8, p. 618 ; 9, p. 697 ; 10, p. 785 ; 11, p. 861 ; 12, p. 937

Alphabetical Index

Aerodynamic Laboratory at Vernon, The : 5, p. 331
After the Geneva Conference : 9, p. 665
After the Ratification by the German Parliament : 4, p. 269
Air Arm of the Future, The : 1, p. 39
Air Express in the United States, The Story of : 11, p. 853
Air Hostess Told Us, The : 1, p. 47 ; 4, p. 243 ; 7, p. 512 and p. 516 ; 8, p. 589
Air Navigation in the Arctic : 2, p. 112
Air Shows?, What Use are : 8, p. 573
Air Transport, A New Era in : 1, p. 42
Air Transport Association's " Facts and Figures " for 1954, The : 7, p. 529
Air Transport before the Camera, Eastern European : 12, p. 917
Air Transport Can Avoid a Crisis : 4, p. 238
Air Transport Crisis Justified?, Is Talk of an : 4, p. 235
Air Transport Diagnoses its Ills and Prepares for Tomorrow : 4, p. 247
Air Transport in A.D.2005, " Fifty Years On "— : 1, p. 44
Air Transport in an Undivided World, Long-Range : 12, p. 908
Air Travel—1985 : 4, p. 240
Aircraft for Short and Medium Stages, New : 10, p. 764
American Antidote to Enemy Atom Bombers, An : 5, p. 330
America's Exhibitors at Paris : 6, p. 423
Arctic Flying, The Importance of : 2, p. 88
Atomic Energy in Search of a Market : 11, p. 847
Atomic Energy—The Power of the Future : 1, p. 46
Aviation Electronics : 11, p. 846
Aviation Traders Accountant : 10, p. 777

B-52 in the Torture Chamber, The : 11, p. 856
Back to Luxury : 4, p. 255
Belgian Participants : 6, p. 422
Bendix Polar Path Compass System, The : 3, p. 196
Bonn, Situation Report from : 6, p. 432 ; 8, p. 615 ; 9, p. 707 ; 12, p. 989
Book Reviews : 1, p. 55 ; 2, p. 128 ; 3, p. 200 ; 5, p. 337 ; 6, p. 448 ; 7, p. 534 ; 9, p. 710 ; 11, p. 864 ; 12, p. 943
Boundary Layer Control, Improving Lift by : 12, p. 925
Bright Decade Ahead—If..., A : 4, p. 240
Britain and Guided Missiles, " Hush, It's Top Secret " : 5, p. 314
Britain's Participation in the Paris Salon 1955 : 6, p. 409
British Aircraft Industry's Post-War Exports, The : 11, p. 832
British Aviation in 1954-55 : 9, p. 686
British Ground Aeradio Equipment, Trends in : 9, p. 703
British Navaids : 9, p. 701
British Rockets at the R.A.E.'s Jubilee Exhibition, Farnborough July 1955 : 9, p. 694
By Arild Viking to the New World : 2, p. 90

Canadian International Air Show : 8, p. 613
" Castles in the Air " at the Turn of the Century : 1, p. 24
Celestial Air Navigation, Thirty Years of : 2, p. 126
Civil Helicopter in Britain, The Future of the : 9, p. 692
Coleopter, The—A Formula for Economy : 1, p. 29
Coleopter Wing, Structural Principles of the : 1, p. 53
Comet Inquiry, Some Reflections on the : 4, p. 257
Commercial Aviation in the Forefront of Progress : 4, p. 246
Communist China's Air Build-Up : 6, p. 431
" CONAD " : 4, p. 260
Convair-Liner 440 : 10, p. 781
Cooperation : 10, p. 756
" Crisis " is Too Strong a Word : 4, p. 244

De Havilland Comet 4 : 10, p. 769
Deutsche Lufthansa over the Atlantic : 12, p. 919
Draken, Double Delta for : 12, p. 932

" Electronic Artillerymen ", A School for : 9, p. 699
End of a Honeymoon? : 4, p. 261
Engine Display, Snapshots of the : 11, p. 839
Engineering Problems of Manned Space Flight : 7, p. 506
Engines for Tomorrow's Airliners, The : 4, p. 252
Equipment Industry in Paris, The : 8, p. 594
Equipment Round-Up : 2, p. 124 ; 3, p. 199 ; 4, p. 270 ; 6, p. 444 ; 8, p. 594 ; 10, p. 790 ; 11, p. 840
European Aeronautical Congress Paris December 14th-18th, 1954, First : 2, p. 123
European Idea is Gaining Ground, The (A.I.C.M.A.'s Fifth Annual Meeting in Rome May 20th-21st, 1955) : 7, p. 522

Farnborough, First Impressions of the 16th S.B.A.C. Display : 10, p. 787
Farnborough in Pictures : 11, p. 834

Fire Control Systems : 5, p. 333
Fiumicino Intercontinental Airport : 7, p. 520
Fokker Friendship : 10, p. 775
Fouga CM. 170 Magister a Standard N.A.T.O. Trainer : 1, p. 48
French Aircraft Industry in 1955, The
I. France's Reorganized Industry Pioneers in New Design Fields : 6, p. 382
II. Neck and Neck with Foreign Rivals: 6, p. 387
From Short Life to Pocket-Size Aircraft : 3, p. 163
From the Solar Column to the Universal Time Clock : 2, p. 116

Gee System of Navigation, The—P. G. Day & K. W. King : 12, p. 941
Geneva International Air Circus : 8, p. 603
Guided Missiles for Home Defence : 5, p. 318

Hallo, Elysées 20-60—Air France's New Management : 6, p. 447
Handley Page Herald : 10, p. 779
Helicopter Goes Mountaineering, The : 8, p. 607
Hurel-Dubois HD.32/HD.321 : 10, p. 778

I.A.T.A., A Decade of the New : 10, p. 749
I.A.T.A. in New York : 12, p. 923
" Ice Water Imperialism " : 2, p. 87
(Idlewild) How Big is Big? : 6, p. 429
" ILSY 5 " : 7, p. 528
Introductory Remarks : 1, p. 20
Iron Curtain?, How Impenetrable is the : 5, p. 324
Italy at the 21st Paris Show : 6, p. 417

Jet Production in Canada : 7, p. 524
Jet Flap, The : 12, p. 931

Last Weapon but One, The : 5, p. 299
Le Bourget, Model Gallery at : 8, p. 590
Le Bourget—June 19th, 1955 : 8, p. 574
Le Bourget—The Engines Salon : 8, p. 592
Let's Land On ! : 4, p. 262
Lightweight Simplified Combat Aircraft, Design of : 3, p. 172
Lockheed Electra : 10, p. 774
Long Range Aircraft, The Next Generations of : 4, p. 267
Long-Range Aircraft for Tomorrow's Air Transport : 12, p. 911
Long-Range Commercial Transports of the Coming Decade : 1, p. 26
Long-Range Missiles will make Peace Unavoidable : 5, p. 310

Mass Transportation by Air Lies in Aircoach Expansion : 4, p. 242
Mechanics of Flow on Annular Wings, The : 1, p. 51
Miniaturization of Aircraft, The : 3, p. 170
Miniaturized Avionics : 3, p. 183
" MOUSE " Project, The : 7, p. 502
Mr. Reader, The Mind of : 2, p. 130 ; 6, p. 446 ; 11, p. 866 ; 12, p. 944
Munich/Oberwiesenfeld, Air Display at : 11, p. 859

N.A.C.A. Investigates " The Heat Barrier " : 7, p. 511
N.A.C.A. Investigates Prevention of Fire and Passenger Safety in Crash Landings : 10, p. 782
N.A.T.O., Five Years of : 3, p. 194
N.A.T.O. ?, How to Sell : 6, p. 381
N.A.T.O. Exercise " Carte Blanche " : 8, p. 614
Netherlands' Contribution, The : 6, p. 421
Next Fifty Years, The : 1, p. 19
" Nike " : 5, p. 317
Nineteenth Century Prophet, A : 4, p. 256

On Top of the World : 7, p. 504
One Idea, One Programme : Four Countries : 3, p. 164

P-16 A Swiss Jet-Powered Combat Aircraft : 6, p. 442
Parachutes are Specialized : 7, p. 515
Peace..., Talking of : 12, p. 897
Peace Did Break Out, If-A. Huber : 12, p. 899
Petter, Interview with W.E.W. : 3, p. 179
Piloted Fighter ?, A New Lease of Life for the : 8, p. 585
Polar Flying, Brief History of : 2, p. 110
Pole, Mounting Guard at the : 2, p. 98
President Eisenhower Offers : 9, p. 666
President Eisenhower's Proposal : 9, p. 683
Professor Einstein's " Folly " : 9, p. 684
Programmes and Projects for Pocket-Size Combat Aircraft : 3, p. 168
Progress in Pictures : 4, p. 264

Radar and Television at Orly Airport, Paris : 2, p. 120
Radar... Electronic Eyes for Air Warning and " Automatic Pursuit " : 12, p. 906
Radar Installations at Zurich-Kloten Intercontinental Airport : 2, p. 118
Reaching for the Stars : 1, p. 22
Rescue and Supply Work by Air in Greenland : 2, p. 107
Retractable Ramjets, Two-Dimensional : 3, p. 197
Richard's Cyclogyros : 11, p. 864
Rocket-Driven Commercial Airliner, The : 5, p. 320
Rocket Research and Production in Italy : 7, p. 513
Rockets and Guided Missiles at the Paris Show : 8, p. 602
Russian Designs, New : 9, p. 680

SAC-CONAD-BALMI : 9, p. 670
Safety Equipment, Airframe and Engine Accessories : 11, p. 840
Silver Jubilee of Air France's South Atlantic Route : 10, p. 758
S.N.C.A.S.E. Caravelle : 10, p. 770
S.N.E.C.M.A. and the Coleopter : 1, p. 35
S.N.E.C.M.A. and Vertical Take-Off : 1, p. 29
Space Flight is Possible : 7, p. 497
Space Ships, Satellites... : 7, p. 497
State of the Art, The : 5, p. 300
Strasbourg, Thoughts on : 10, p. 753
Sub Helps Flying-Boat : 6, p. 436
Supersonic Fighters, " Wasp-Waisted " : 12, p. 928
Sweden's Guided Missile Programme : 7, p. 514

TACAN (British Version) Details Released : 9, p. 705
TACAN UHF Radio Navigation System, The : 10, p. 792
Target Aircraft, Guns, Rockets : 11, p.845
" Television Flight " by 1958 ? : 3, p. 184
Ten Years Preparation for Twenty Years of Flying : 11, p. 825
Towards a New Air Arms Policy : 3, p. 195
Trend Towards Diversification of Production, The : 3, p. 189
Turbine Air Transportation One Step over the Threshold : 10, p. 759
Turbines (Allison 501-D 10 and Bristol BE 25), Two New Civil Propeller : 7, p. 532
Turbojet, Two Rôles for One : 3, p. 181
Turin Show, Preview of the 1955 : 9, p. 695
Tushino 1955... : 8, p. 606

U.S. Aircraft Industry Draws its Balance, The : 9, p. 708
U.S. National Aircraft Show 1955 : 11, p. 860
U.S. Navy's " Flying Platforms ", The : 7, p. 517

VHF or UHF ? : 9, p. 706
Vickers Viscount 800 : 10, p. 774
VORTAC Air Navigation System Controversy, The : 6, p. 449
V.T.O. Chronicle of a Technical Revolution : 1, p. 27

Warsaw Convention, The Revision of the : 11, p. 863
West-East No-Mans-Land in Europe, The : 3, p. 187
West Germany : From Planning to Execution : 11, p. 858
What's in the Air ? : 1, p. 56 ; 2, p. 121 ; 3, p. 192 ; 4, p. 265 ; 5, p. 335 ; 6, p. 433; 7, p. 526 ; 8, p. 618 ; 9, p. 697 ; 10, p. 785 ; 11, p. 861 ; 12, p. 937

INTERAVIA

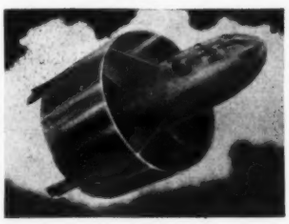
Review of World Aviation

Volume X | No. 1 | 1955

Editor : E. E. Heiman
Executive Editors : P. A. Blackburn, E. Herzfeld, H. Rieck
Associate Editors : J. M. Stroud, E. Baur, H. Lapierre, Ginés de Bracamonte, F. Sanabria
Art Editor : H. W. Mahrer
Layout Adviser : K. Keller
Circulation Manager : G. Deneke

Contents

THE NEXT FIFTY YEARS		19
Introductory Remarks	Th. v. KARMAN, PARIS	20
Reaching for the Stars	G. A. CROCCO, ROME	22
" Castles in the Air " at the Turn of the Century		24
Long-Range Transports of the Next Decade		26
V.T.O. - Chronicle of a Technical Revolution		27
SNECMA and Vertical Take-Off	H. DESBRUÈRES, PARIS	29
The Coleopter - Formula for Economy	H. v. ZBOROWSKI, BRUNOY	29
SNECMA and the Coleopter	H. OESTRICH, PARIS	35
The Air Arm of the Future		39
A New Era in Air Transport		42
Air Transport in A.D. 2005	P. G. MASEFIELD, LONDON	44
Atomic Energy - the Power of the Future		46
The Fouga CM.170 Magister		48
The Mechanics of Flow on Annular Wings	W. SEIBOLD, BRUNOY	51
Structural Principles of the Coleopter Wing	H. HERTEL, BRUNOY	53
Book Reviews		55
What's in the Air?		56



Front cover .

A revolutionary conception : Vertical take-off three-seat civil aircraft of the coleopter type, with annular wing and propeller turbine.

Appears Monthly in Four Editions : English, French, Spanish and German.

Advertising Department : Publishing and Editorial Offices, Subscription Department : Interavia S. A., 6, Corraterie, Geneva. Cables and Telegrams : Interavia-Geneva. Teleprinter : 2 21 22. Postal Cheque Account : Geneva I 5380.

New telephone number: 25 42 34 (five lines)

Annual Subscriptions : U.S.A. and Canada, $7.00 ; United Kingdom and Eire, £1.15.0 ; Commonwealth, £2.6.0 ; Switzerland, 28.— fr. ; Austria, 170.— sch. ; Belgium, 320.— fr. ; Brazil, 230.— Cr$. ; France, fr. 2400.— ; Germany, 27.50 DM ; Holland, 25.— fl. ; Japan, $7.00 ; Norway, 50.— kr. ; Spain, 280.— ptas. ; Sweden, 35.— kr. ; Uruguay, 23.— pesos. All other countries, 28.— Sw. fr.

AGENTS :

Interavia Austria	Postfach 162, Vienna I
Interavia Belgium	5, Heidestraat Noord, Capellenbosch-lez-Anvers
Interavia Canada	21, Hargrove Lane, Toronto 14, Ont.
Interavia France	144, Avenue des Champs-Elysées, Paris 8me
Interavia Germany	Interavia Verlags G.m.b.H., Friedrich Ebert-Strasse 1, Frankfurt/M
Interavia Great Britain	27, Old Bond Street, London, W.1
Interavia Holland	Henk A. Jansen, Olympiaplein 84, Amsterdam-Z
Interavia Italy	30, Via San Marino, Rome 7.23
Interavia Japan	Isogo P.O. Box 3, Yokohama
Interavia South Africa	P.O. Box 6073, Johannesburg
Interavia Spain	Donoso Cortés 85, Madrid
Interavia Sweden	P.O. Box 29, Linköping
Interavia U.S.A.	Head Office: 123 N. Gladys Ave., Monterey Park, Calif. Branch Office: 185 Madison Ave., New York 16, N.Y.

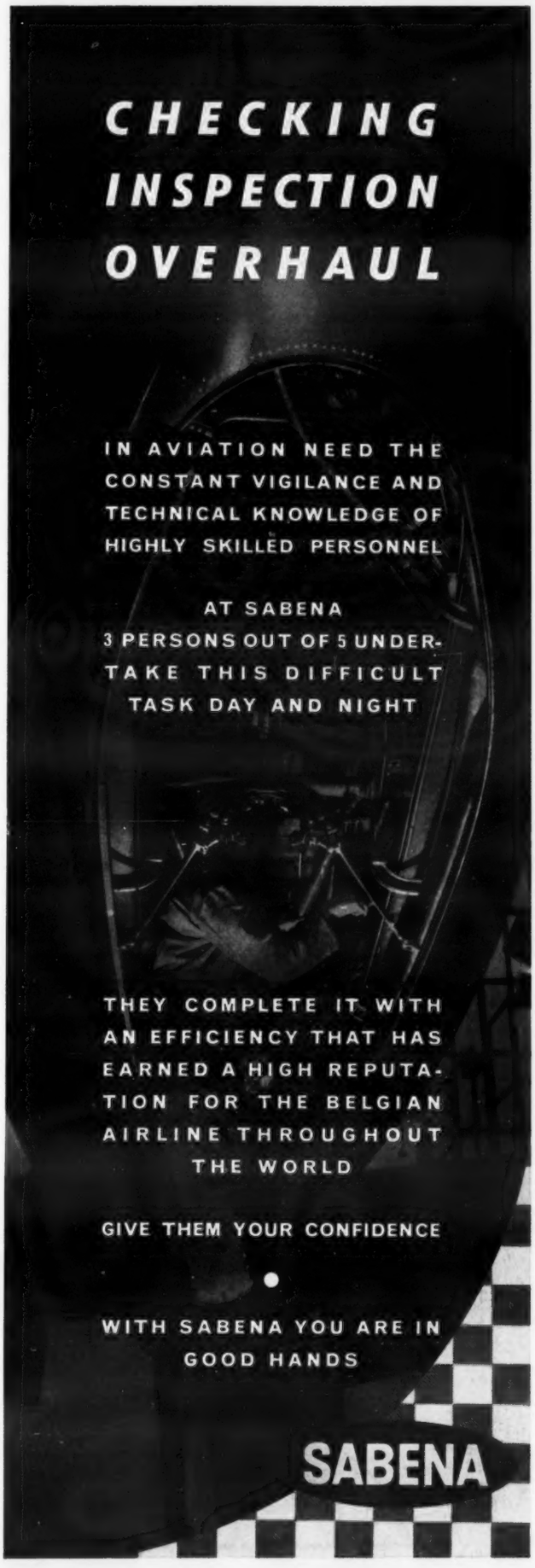
DISTRIBUTORS :

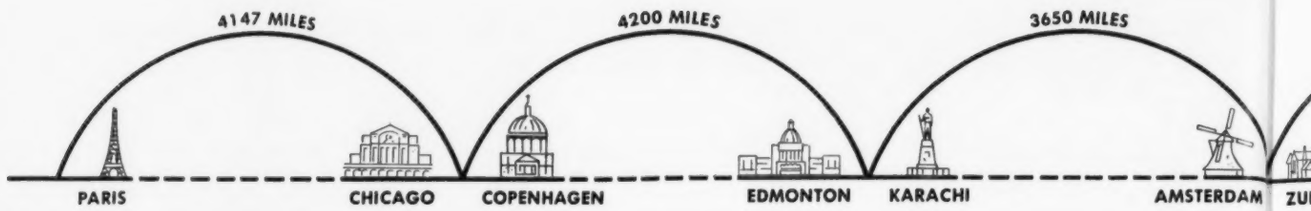
Canada	Wm. Dawson Subscription Service Ltd., 587 Mount Pleasant Road, Toronto, 12, Ont. Edward Company Regd., 4720 Ridgevale Avenue, Montreal 26, P. Q.
Czechoslovakia	Artia S. A., Smecky 30, Praha II
Denmark	Dansk Centralagentur, Stormgade 20, Copenhagen
Finland	Akateeminen Kirjakauppa, Keskuskatu 2, Helsinki Rautatiekirjakauppa Oy, Köjdenpunojank 2, Helsinki
Germany	W. E. Saarbach, Gereonstr. 25-29, Cologne
Hungary	Kultura, Akademia-utca 10, Budapest V
Ireland	Basil Clancy, Esq., Cooleevin, Foxrock, Co. Dublin
Israel	F. Pinczower, P.O. Box 6008, Tel Aviv
Japan	Maruzen Co. Ltd., 6 Tori-Nichome Nihonbashi, Tokyo
Norway	Narvesens Kioskkompani A. S., Box 125, Oslo
Uruguay	Humanitas, Colonia 883, Montevideo

Copyright 1955 by Interavia S. A., Geneva, Switzerland

Printed in Switzerland

Imprimerie de « La Tribune de Genève », Geneva
AG. Fachschriften-Verlag und Buchdruckerei, Zurich


CHECKING
INSPECTION
OVERHAUL
IN AVIATION NEED THE CONSTANT VIGILANCE AND TECHNICAL KNOWLEDGE OF HIGHLY SKILLED PERSONNEL
AT SABENA
3 PERSONS OUT OF 5 UNDERTAKE THIS DIFFICULT TASK DAY AND NIGHT
THEY COMPLETE IT WITH AN EFFICIENCY THAT HAS EARNED A HIGH REPUTATION FOR THE BELGIAN AIRLINE THROUGHOUT THE WORLD
GIVE THEM YOUR CONFIDENCE
WITH SABENA YOU ARE IN GOOD HANDS
SABENA

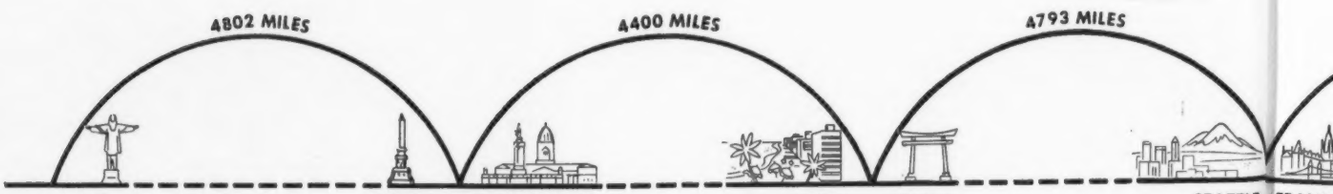


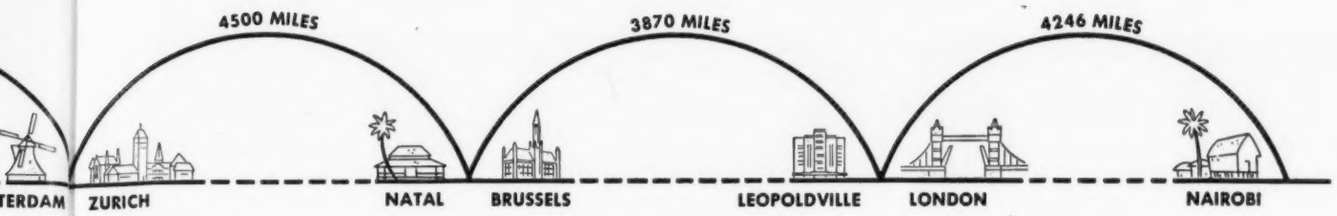
Always Finest and Fastest ...

Now THE WORLD'S
LONG-RANGE, N

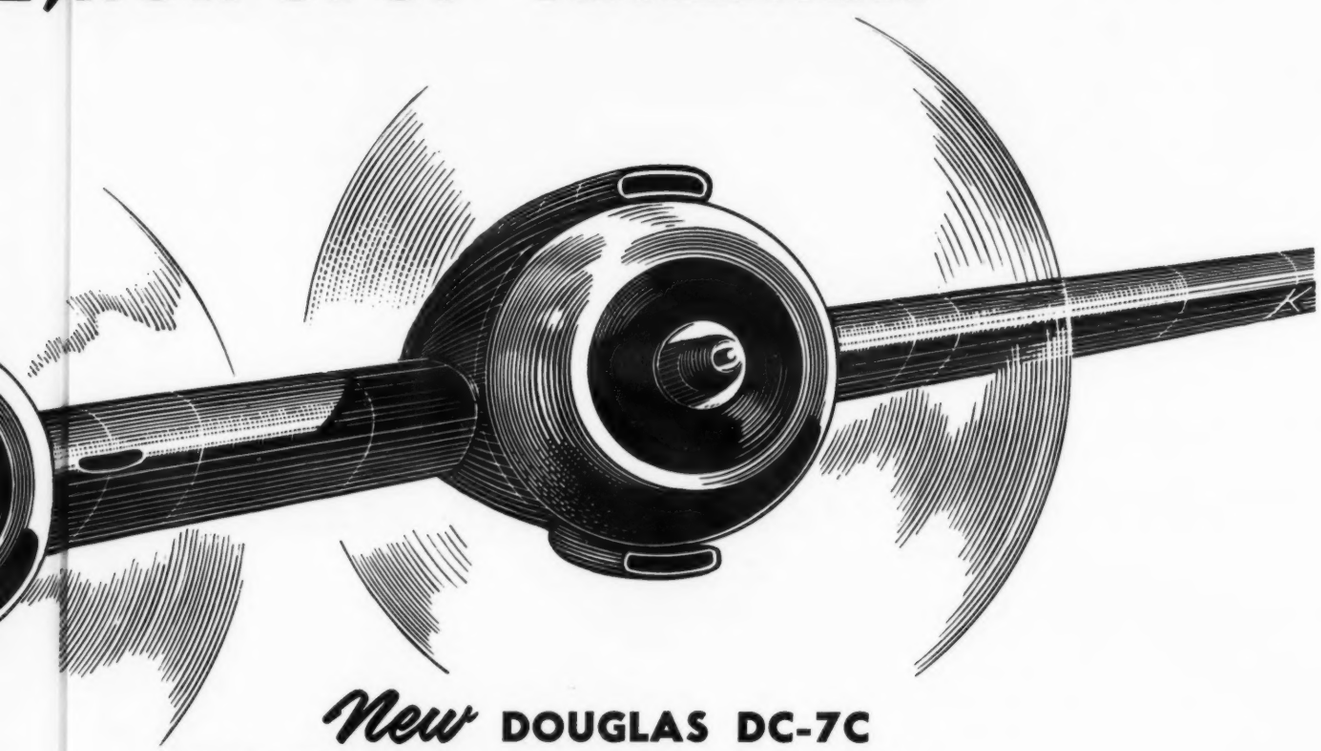
DOUGLAS

Twice as many people fly Douglas as all other airplanes combined.





'S CHAMPION
E, NON-STOP AIRLINER



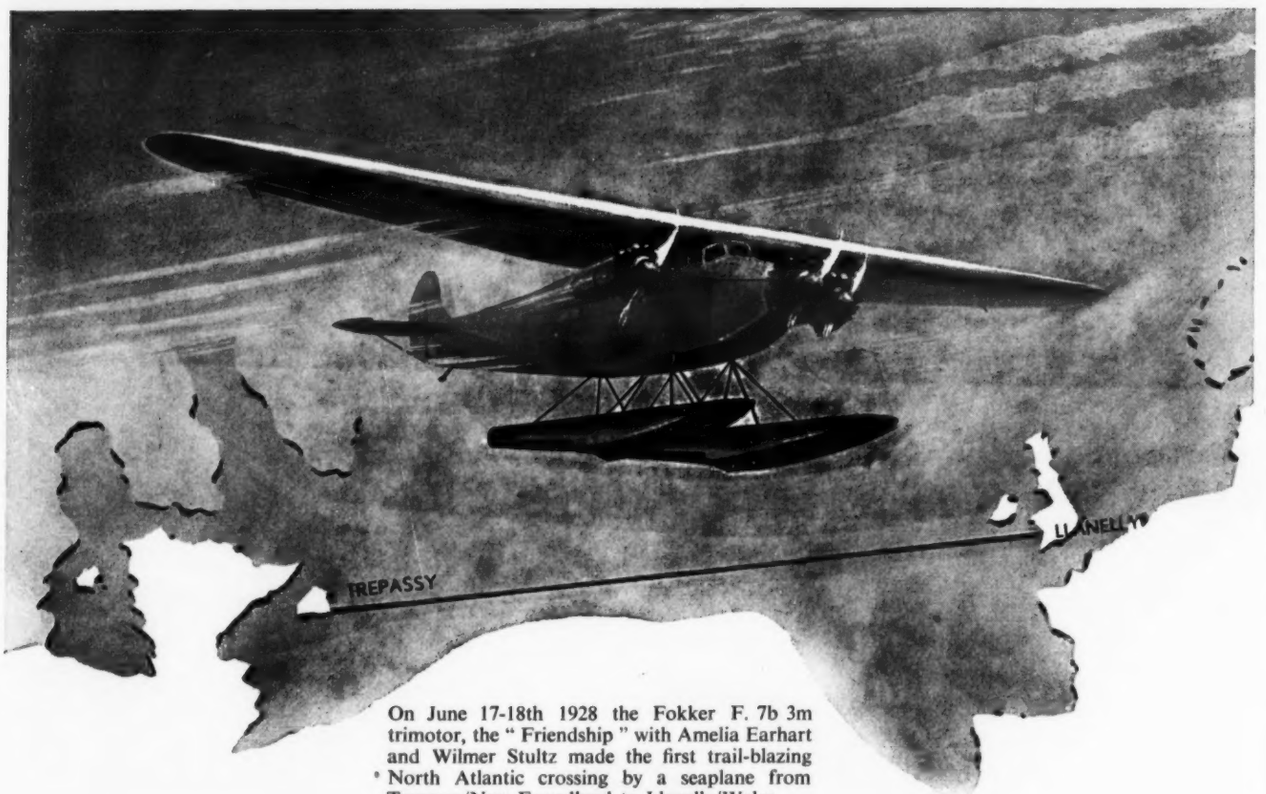
New DOUGLAS DC-7C

Adds 1000 miles to non-stop flight limits
Adds up to 70 mph to cruising speed

Here is the first truly Intercontinental passenger airplane. This Douglas distance champion will carry competitive payloads up to 5000 miles non-stop ... makes possible unrefueled flights like those illustrated ... and because of its range and speed, promises to revolutionize air travel and airline operations between continents.

Longer wings to carry more fuel also allow engines to be moved further away from the cabin, making the DC-7C even more *quiet* and *comfortable*.

Already ordered by Pan American World Airways, these new model transports are scheduled to begin service in 1956.



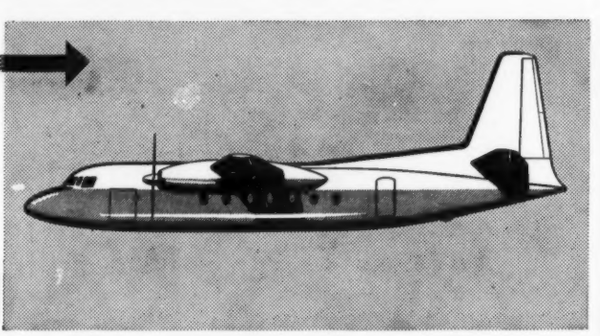
On June 17-18th 1928 the Fokker F. 7b 3m trimotor, the " Friendship " with Amelia Earhart and Wilmer Stultz made the first trail-blazing North Atlantic crossing by a seaplane from Trepassy/New Foundland to Llanelly/Wales.

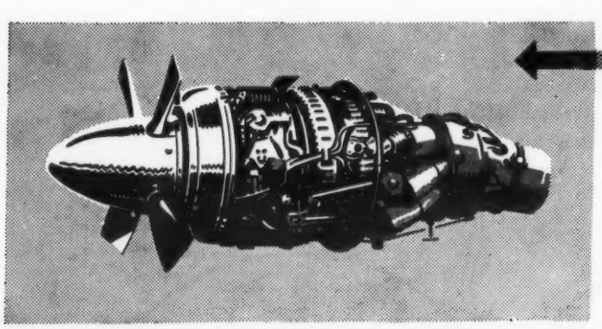
PIONEERS IN THE PAST — Fokker — PIONEERS IN THE FUTURE

FOKKER WILL SPAN THE WORLD AGAIN!

THE NEW FOKKER F. 27 "FRIENDSHIP"

twin-turboprop airliner for 28-36 passengers in which more than 35 years of experience in commercial aviation is incorporated, is the most suitable transport for short to medium range traffic available, meeting both ICAO and CAR 4b requirements.





THE ROLLS-ROYCE "DART" TURBOPROPS

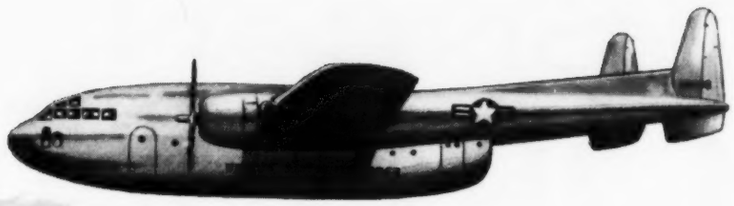
with which the " Friendship " is powered are the most reliable propeller-turbines available for this type of aircraft. They allow economical operation in all climates and safe and vibrationless flight at 20,000 ft.

* * *

ROYAL NETHERLANDS AIRCRAFT FACTORIES FOKKER

SCHIPHOL-ZUID

TEL. ADDR.: FOKPLANES-AMSTERDAM



FLYING HIGH AT 40° BELOW

In those frozen outposts of the free world—outlying areas of everlasting ice and snow—rugged Fairchild *Flying Boxcars* deliver personnel and bulky equipment when they are needed—where they are needed.

Supplying strategic military outposts with everything from bulldozers to prefabricated buildings and runways, combat-proven C-119's land and take-off surely and safely on the world's toughest terrain.

These vital missions are typical of the C-119's ability to haul big payloads anywhere—and they prove, once again, the dependable all-weather performance that has helped make the *Flying Boxcar* world-famous.

ENGINE AND AIRPLANE CORPORATION

FAIRCHILD

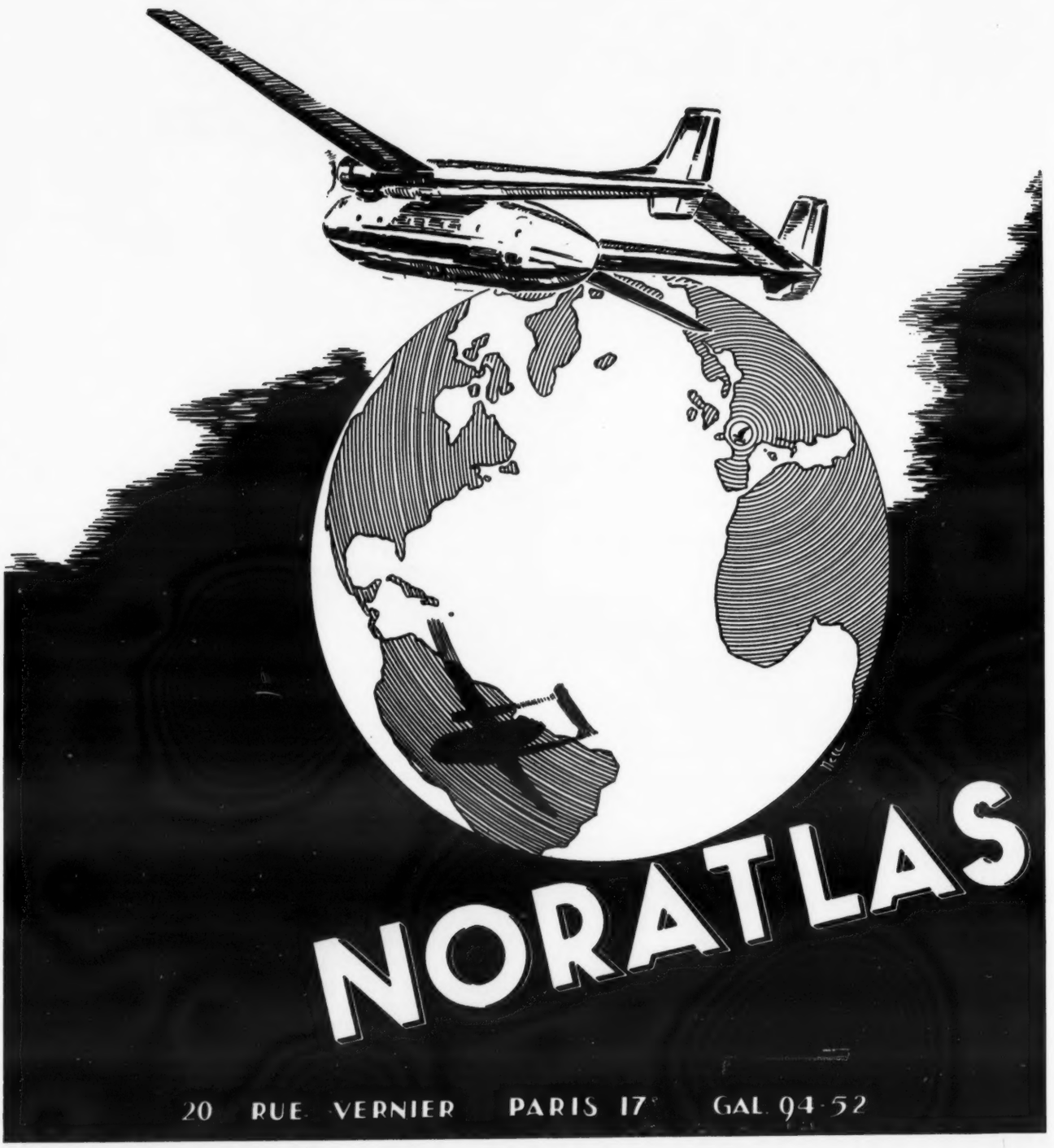
Aircraft Division

HAGERSTOWN, MARYLAND

Other Divisions:
American Helicopter Division, Manhattan Beach, Calif.
Engine Division, Farmingdale, N. Y.
Guided Missiles Division, Wyandanch, N. Y.
Kinetics Division, New York, N. Y.
Speed Control Division, St. Augustine, Fla.
Stratos Division, Bay Shore, N. Y.

SNCAN

NORD 2501



20 RUE VERNIER PARIS 17e GAL 94-52

Life line of communication ...

In 1906 Marconi's carried out their first experiments in ground to air radio. Today more than 40 airlines and 20 airforces fit Marconi equipment and Marconi ground installations are in use throughout the world's airports. The foresight and enterprise that have developed the communications on which elaborate modern aircraft operation relies are still alive. Marconi research today is making possible and safe still further progress.

NAVIGATIONAL AIDS

AIRBORNE RADIO SYSTEMS

AIRPORT RADIO SYSTEMS

MARCONI

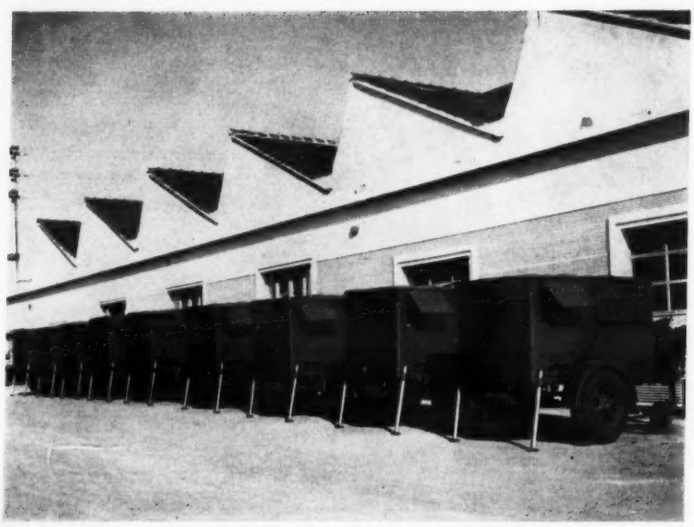
Planning & Installation of Airport and Airborne Systems

MARCONI'S WIRELESS TELEGRAPH COMPANY LIMITED · CHELMSFORD · ESSEX

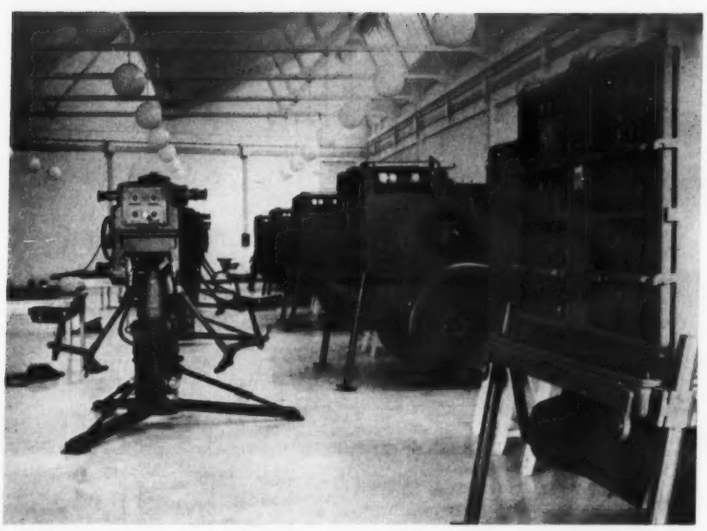
CONTRAVES ITALIANA

F90 COMPUTER
T90 TRACKER

for A. A. 90 mm. batteries



CONTRAVES ITALIANA S. p. A.
ROMA
LUNGOTEVERE DELLE ARMI 12



SOCIÉTÉ NATIONALE

D'ÉTUDE ET DE CONSTRUCTION DE MOTEURS D'AVIATION

150, Bd HAUSSMANN · PARIS 8e

TAKE YOUR NEXT EUROPEAN TRIP BY

VICKERS VISCOUNT

THE AIRCRAFT APPRECIATED BY THE EXPERTS

Air France has just equipped its main European services with the modern aircraft best suited to medium-stage routes, the Vickers "Viscount". With its four Rolls-Royce "Dart" turboprops, the "Viscount" has a cruising speed of 320 m.p.h. at 25,000 ft.

For the pilot it is the most "docile" of aircraft, for the passenger the most comfortable. No more noise on board, no vibration, a maximum of air volume, a maximum of visibility. Fully sound-proofed and pressurized, the cabin is 40 ft. long and nearly 10 ft. wide, with big windows giving passengers a wide view outside.

Air France "Viscounts" operate services every day to :
London, Hamburg, Stockholm, Geneva.
Every weekday to Rome.
Four times a week to Copenhagen.
Three times a week to Vienna, Munich, Milan.
All these services, except the special "Epicurien" service to London, are tourist class.

Air France serves 35 cities in Europe. Its network is the longest in the world, with 230 points of call in 72 countries and five continents.

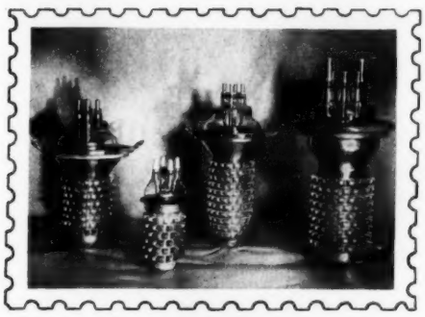
AIR FRANCE *35 years experience at your service*

INFORMATION FROM TRAVEL AGENCIES OR AIR FRANCE OFFICES IN PARIS, LYONS, STRASBOURG, NANTES, BORDEAUX, MARSEILLES, TOULOUSE AND NICE

Cie FRANÇAISE THOMSON-HOUSTON

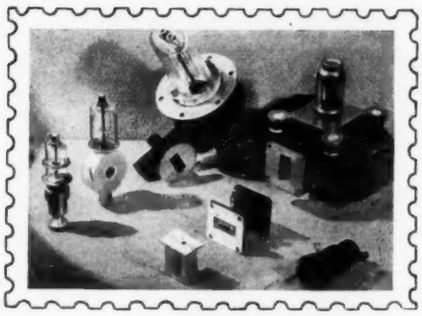
IN THE FRONT RANK OF EUROPEAN

ELECTRONIC MANUFACTURERS



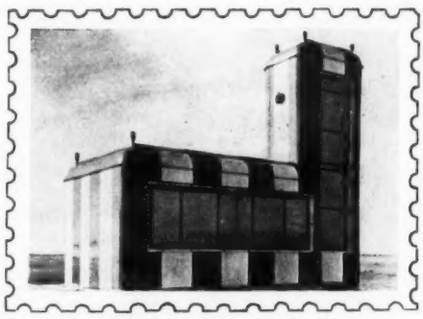
VAPOTRONS

CFTH



VHF TUBES

PORTABLE TRANSMITTER-RECEIVERS

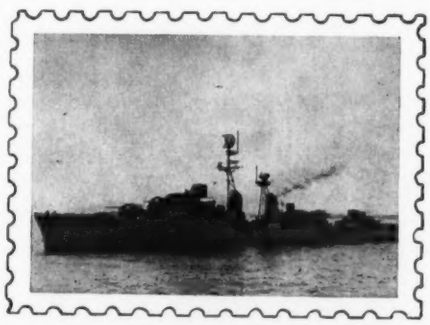


G.C.A. EQUIPMENT

RADIO-COMMUNICATIONS

AUTOMATIC RADAR

High-power
RADAR

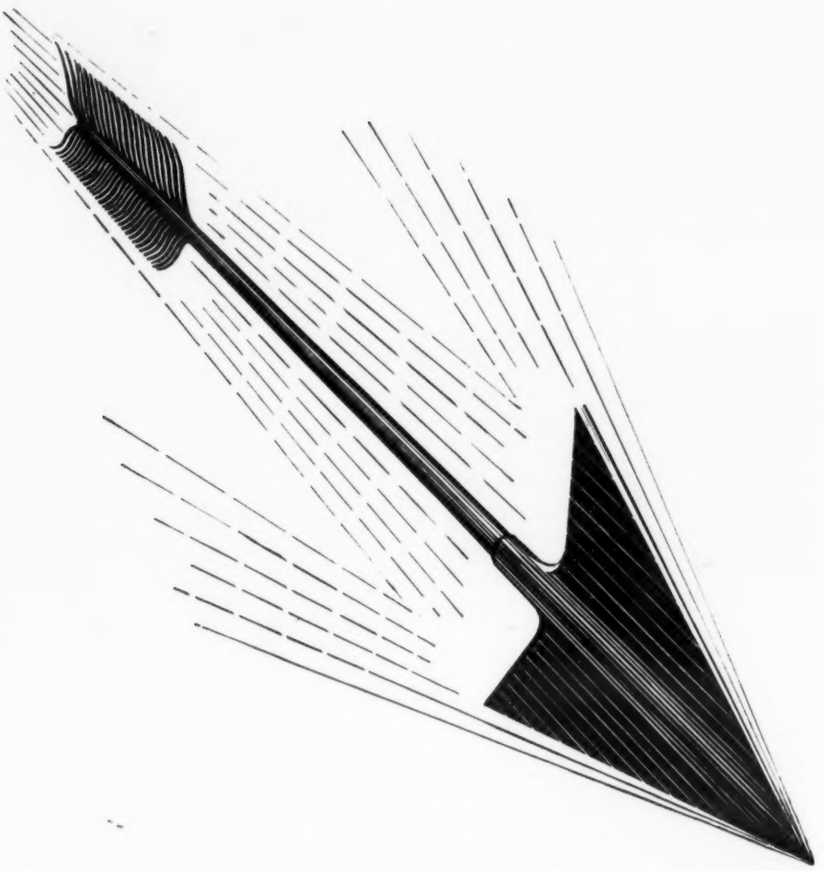


MARINE RADAR

COMPAGNIE FRANÇAISE THOMSON-HOUSTON

GROUPE ÉLECTRONIQUE

173 Bd Haussmann Paris (8) Tél. ELYsées 83.70 Télégr. ELIHU-42-Paris



HIGH AERODYNAMIC EFFICIENCY

The Napier Eland is a propeller-turbine aero engine with an outside diameter of only 36 inches. This gives it unusually high aerodynamic efficiency. Fuel consumption is low and its light weight permits great economies in the size and weight of both civil and military aircraft.

NAPIER Eland

Partners in Progress with The ENGLISH ELECTRIC Company Ltd.
D. NAPIER AND SON LIMITED. LONDON, W. 3.

Le Vautour

The speed of a fighter
The power of a bomber

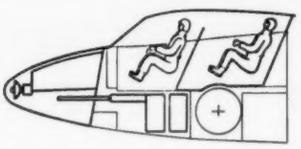
The VAUTOUR is being mass-produced in its three versions for the French Air Force

Comfortably exceeding the speed of sound, it is one of the fastest planes in the world in its category • The ease with which it can be converted permits economical standardization of manufacture and use • It can readily be equipped with any of the most powerful jet engines, such as the ATAR, AVON, SAPPHIRE • Owing to its large capacity and useful load, the VAUTOUR has a long flight endurance (several hours) and can carry a very powerful armament • It can operate from short or makeshift strips.

The VAUTOUR is the combat aircraft best suited to European needs

SNCASO

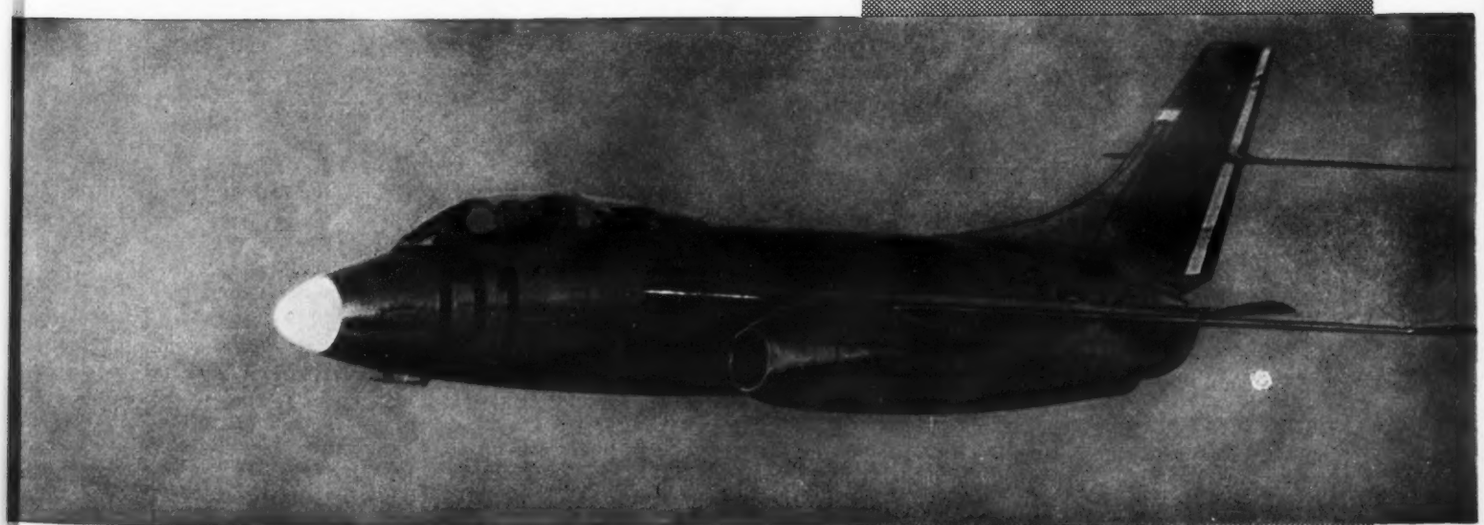
3 VERSIONS



All-weather fighter

Ground attacker

Bomber



SOCIETE NATIONALE DE CONSTRUCTIONS AERONAUTIQUES DU SUD-OUEST

105, AVENUE RAYMOND-POINCARÉ - PARIS 16e - Tél. KLEber 32-20

NOW!

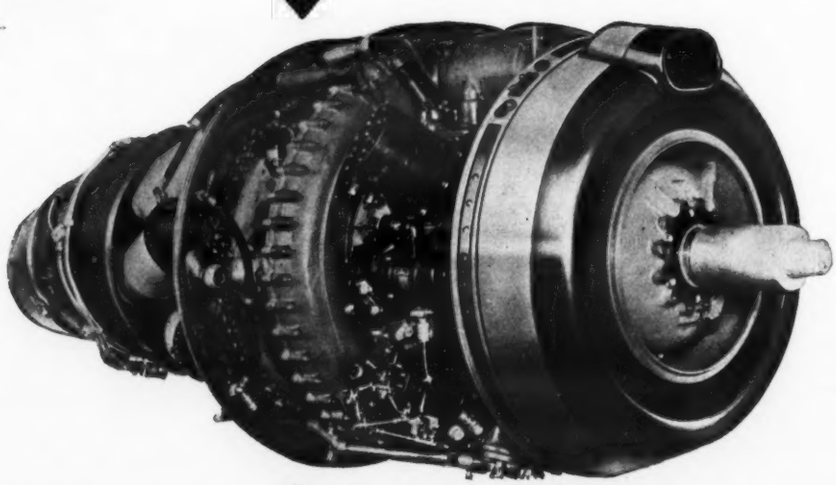
Prevent ice formation with electrically heated rubber mats

DESIGNED AND PRODUCED BY

DUNLOP

Latest development by Dunlop in the important field of ice-prevention in aircraft is a thermal anticing system on the electric blanket principle—heater circuits sandwiched between layers of synthetic rubber. These sandwiched circuits, tailored to fit individual applications, are attached directly to metal surfaces and do not impair aerodynamic efficiency.

The system may be heated continuously or in cycles or in a combination of both by means of a controller. With an ice detector the installation is fully automatic. The illustration shows the Rolls Royce Dart jet engine. This Dunlop Thermal Anticing innovation is also suitable for heater intakes, air intakes, radio antennae, spinners and shutters.



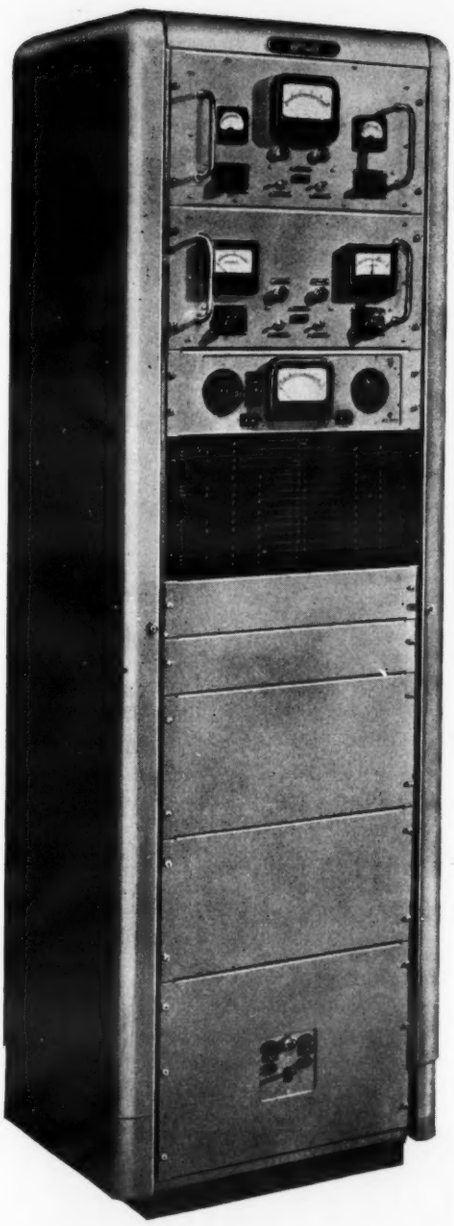
DUNLOP RUBBER CO. LTD. (AVIATION DIVISION)
FOLESHILL · COVENTRY · ENGLAND
DEPOTS THROUGHOUT THE WORLD

4X/91

PYE ERICSSON

SEVEN CHANNEL

VHF FM RADIO TELEPHONE SYSTEM



This 7-channel Radio Link System has been designed for economy both in initial cost and maintenance demands.

This has been achieved without sacrifice of essential facilities or relaxation of performance standards. Both Radio and Carrier equipment for the 7-channel terminal is housed in a single 6-foot cabinet as illustrated.

The equipment is fully tropicalized and suitable for continuous unattended operation in all parts of the world.

ABBREVIATED SPECIFICATION

Radio Frequency Range 60—216 mc/s
Transmitter output Power
10 watts, or with Amplifier unit—50 watts
Baseband (7 Channels) 0.3—23.4 kc/s
Maximum Deviation 50 kc/s
Receiver Bandwidth
6 db down at ±120 kc/s

Telecommunications

CAMBRIDGE ENGLAND

Pye New Zealand Ltd. Auckland C.I., New Zealand	Pye Canada Ltd. Ajax, Canada	Pye-Electronic Pty., Ltd. Melbourne, Australia	Pye Ireland, Ltd. Dublin, Eire
Pye Radio & Television (Pty.) Ltd. Johannesburg South Africa	Pye Limited Plaza de Necaxa 7 Mexico 5	Pye Limited Tucuman 829 Buenos Aires	Pye Limited 5th Avenue Building 200, 5th Avenue, New York

PYE LIMITED . . CAMBRIDGE . . ENGLAND

Canberra B 8 'Night Intruder'

The Canberra B 8 is the most versatile of the Canberra series. It can readily be converted to perform a number of rôles, including night intrusion, high altitude bombing and target marking. In its Night Intruder rôle it carries underwing armament and forward-firing cannon in the bomb bay. The offset fighter-type canopy gives the pilot a superb all-round view and the re-designed navigator's compartment provides better vision and a wider range of navigational aids.

'ENGLISH ELECTRIC'
Canberra
ROLLS-ROYCE AVON JET ENGINES

THE ENGLISH ELECTRIC COMPANY LIMITED QUEENS HOUSE · KINGSWAY LONDON WC2

INTERAVIA

Deadline Notes

No. 1, 1955

N.A.T.O. COUNCIL AND ATOMIC WEAPONS

The December meeting of the N.A.T.O. Council (Foreign Ministers and Defence Ministers) examined a detailed report by the N.A.T.O. military staff committee (Chiefs of Staff of the N.A.T.O. countries) on present defence preparedness and arms planning for 1955, 1956 and 1957. - The main features of the eight-point final communiqué were as follows:

a) Air defence continues to be the critical item in N.A.T.O.'s preparedness programme, and it is therefore gratifying that the U.S.-Dutch negotiations have resulted in agreement on the creation of a technical air defence centre at The Hague. The collaboration of all leading air defence experts in the new air defence committee will make rapid progress possible.

b) As regards atomic weapons, agreement had been reached on the necessity of the general adoption of the most up-to-date arms. N.A.T.O. headquarters will initiate the equipment of the national defence forces with atomic weapons. However, the decision on the use of atomic weapons in the event of aggression will not be made by N.A.T.O.'s military commands but by the N.A.T.O. Governments.

c) The training programme must be improved and expanded, possibly with an extension of the present compulsory military training periods in certain countries (Belgium, Denmark and Holland have recently reduced this period).

A.I.C.M.A. MEETING

The Association Internationale de Constructeurs de Matériel Aéronautique (International Association of Aircraft Manufacturers) took the following decisions at its Paris meeting: Common utilization by all European aircraft engineering associations of the Netherlands wind tunnel installations; construction of a supersonic wind tunnel at the Institut Aérotechnique de Saint Cyr, France; approval of the admission to A.I.C.M.A. of the German Industries Association, following ratification of the London and Paris Treaties; with Germany, A.I.C.M.A. will cover virtually all Continental European countries engaging in aeronautical manufacture (10). - The next meeting of the A.I.C.M.A. Committee will be held in Paris in March 1955; General Meeting in Rome on May 20th, 1955.

"MASSIVE TRANSPORTS" FOR THE U.S. AIR FORCE

Brigadier General John P. Doyle, Director of Transportation for the U.S. Air Force has announced the design of "gigantic air cargo carriers" which will be capable of carrying 50 tons of cargo 3,500 miles across the Atlantic non-stop in eight hours. - The same subject was discussed by Donald W. Douglas, Founder-President of Douglas Aircraft Co., in a lecture to 600 representatives of Government agencies and industry in Washington: the U.S. aircraft industry, he said, is ready today to produce huge conventionally propelled air transports. A new conception of aircraft could carry a payload of 100,000 lbs. at a speed of 500 m.p.h. over a range of between 1,500 and 3,500 miles. Nine of these aircraft could perform the same work as 171 Douglas C-54 Skymasters or 58 Douglas C-124 Globemasters, at one third or one fourth of the operating cost and in less than half the time.

R.A.A.F. EQUIPMENT PLANS

Australia's mission now overseas on a survey of suitable material for the future re-equipment of the Royal Australian Air Force is expected to present its report to the Federal Government in February. Although further overseas visits will be made later to make a more detailed study of recommended types, the initial selection seems to be tending towards the Lockheed F-104 for the fighter, the Lockheed C-130A for the transport and the delta-wing Avro Vulcan for the strategic bomber. However, there are arguments on the latter as a result of the recent visit by a Handley Page mission in support of the crescent-wing Victor.

20th ANNIVERSARY OF K.L.M.'s WEST INDIES DIVISION

In January, 1955, K.L.M. celebrates the 20th anniversary of the foundation of its West Indies Division

* From INTERAVIA's world-wide news service, including INTERAVIA AIR LETTER, the daily international aviation news digest. — No part may be reproduced without written permission.

(with headquarters in Curaçao), which now operates a 12,500-mile network in the Caribbean, Central America and the northern part of South America.

WING-TIP TANKS FOR K.L.M. SUPER CONSTELLATIONS

K.L.M. announces that the four Lockheed Super Constellations on order for the spring of 1956 are to be equipped with wing-tip tanks (capacity 600 U.S. gals. each). It is also planned to fit additional tanks to the twelve Super Constellations already in service, so that the intermediate landing in Gander, Newfoundland, can be eliminated on the Amsterdam-New York route.

SWISSAIR JOINS "PAY LATER" SCHEME

Swissair too has decided to sell tickets by instalments, as an experiment, but for the time being the system will be restricted to the United States. Down payment 10%, remainder in monthly instalments (a U.S. banking institute will handle the credit arrangements).

ITALIAN CROSS OF MERIT FOR GEORGES HEREIL

During the Paris meeting of A.I.C.M.A. George Héreil, President of Honour and founder of A.I.C.M.A., President of SNCA du Sud-Est, was awarded the Grand Cross of the Italian Order of Merit.

NEW SAAB SAFIR PRODUCTION

Production has started of a new series of Saab-91 Safir all-metal low-wing monoplanes. Reason for this decision is the increased capacity at Linköping and the good export prospects for this aircraft. The Safir is used by military and private flying schools in eight countries.

EXPANSION OF SVENSKA FLYGMOTOR

A large-scale expansion of the activities of Svenska Flygmotor A.B., at Trollhätton is planned, including investment of Kr. 20,000,000 and a considerable increase in labour force, Cunnar Engellau, President of the company recently told his staff. New agreements with the Swedish Air Force cover a production programme until the end of 1962.

CONVAIR TO CONTINUE 340 PRODUCTION

A statement by Director of Contracts J. G. Zevely indicates clearly that the Convair Division of General Dynamics Corp. - despite reports to the contrary - is to continue production of the Convair Liner 340. "Convair's plans for a new turboprop commercial transport airplane will not interfere with the continued manufacture of the Convair Liner 340... An improved Model 340 will be available for delivery in twelve months from order... Production of several military versions of the original Model 340 has reached an accelerated rate and will continue well into 1956."

MARTIN NUCLEAR DIVISION

The new Nuclear Division set up by Martin Aircraft Co., of Baltimore, will develop lightweight airborne nuclear power plants which can be flown into areas where normal electric power supplies have been cut off.

WORKSHOP BRIEFS...

A second prototype of the Fairey Rotodyne (two Napier Elands) is to be equipped as cargo transport for military and civil use. * Pratt & Whitney J-57-P-13 turbojets of approx. 10,000 lbs. take-off static thrust each are to be used in the McDonnell F-101A Voodoo long-range fighter and A-bomb carrier. * The U.S. Air Force's Air Research and Development Command has awarded development contracts for small turbojets to Fairchild and General Electric. * The SNECMA Vulcain reached 13,200 lbs. static thrust during recent bench tests. * Gyrodyne Co.'s one-man "rucksack helicopter" bears the designation XROE-1. It is under development for the U.S. Marine Corps. * Fokker is to begin quantity production of the F.27 Friendship in January 1955. * Bristol announces a new version of the Bristol Olympus high-performance turbojet, the BO1.6. * Link Aviation, of Binghampton, New York, is making a flight simulator for pre-flight training on the Cessna T-37A jet trainer, to the order of Air Materiel Command. * The second of the two Bréguet 960 Vultur prototypes is being modified to serve as model for a new light Navy aircraft with turboprop power. It will be known as the Bréguet 1050 and will be ready for flight testing in the spring. - The first prototype of the 960 is also being modified and fitted with a device for boundary layer suction. * Pan American has ordered a Curtiss-Wright flight simulator for the training of DC-7C crews. * Lear, of Santa Monica, Calif., has brought out a new VHF transmitter and receiver, the LTR-6GH, with 10 Watt crystal controlled transmitter. Frequency range 108 to 127 mc/s; push button tuning to 112.8 mc/s. * Strength tests on components of the SE.210 Caravelle jet commercial transport: cabin windows took 16 times the normal pressure, and deeply scored windows as much as 10 times, without breaking. * Bell XH-13F, experimental turbine version of the Bell 47 helicopter, has begun flight testing; power plant: Continental-Turboméca Artouste.

* * *

The Next Fifty Years

A year ago the 50th anniversary of powered flight was marked with pomp and ceremony. With all due regard for national sensitivities, it must be admitted as a historical fact that the Wright Brothers made the first four powered flights on December 17th, 1903. However, even the Americans will admit that flying is not their national product or monopoly, but the result of the efforts of all nations. So much for the first 50 years.

On this threshold of the second half of aviation's first century, the Editors do not propose to approach the reader with wild prophecies but have endeavoured to provide him with reasoned forecasts. Even this is hazardous enough . . . There is one point, however, on which all must agree with the scientists, industrialists, engineers, military staffs, air transport men and airport managers: basically speaking, we are only at the beginning. It may safely be hazarded that there must and will be revolutionary developments before flying really gets out of its infancy. But there is no room for Jules Verne fantasies or sensational and nerve-racking stories.

The present issue therefore begins with a past master of aeronautical research, the aerodynamicist *Theodore von Karman,* to whom a round dozen universities have shown their respect in the form of honorary degrees. Professor von Karman, whose research results fertilized a whole generation of science, recognizes with a certain self-denial that—with all honour due to aerodynamics—the "motorist" will have the next word. A *radical change in take-off and landing methods* is quite indispensable in his view—and all the authors in the issue agree with him there. In common with his friend G. A. Crocco—who follows him immediately in these pages—he forecasts an age of "aero-thermodynamics", in which new branches of research such as "aero-thermochemistry" and other still obscure questions will play an important part.

A native of the nation that has enriched the world with thousands of scientists in all branches—for example, Marconi and Fermi, to mention but two of the more recent names—G. *A. Crocco* deals with the difficult subject of space travel rockets, which are so widely discussed on all sides today . . . Such distant prospects can best be discussed by a serious scientist. It is sensation enough that a man of this calibre should confess his belief in *space travel.*

Turning the pages further, *Interavia's Study Group* has prepared a forecast of the "Air Arm of the Future", based on material publicly available. Atom and hydrogen bombs are already established facts, but the *bomb-carrier* will change radically. Sooner or later the day of the ten-engined B-36 will belong to the past. The sharp distinction between bomber and fighter will become outdated. Tomorrow's fighter-bomber will also be an A-bomb carrier. And when the "motorist" gets his say, he can be expected to open up new prospects by doing away with the horizontal take-off and landing methods which are becoming more and more impracticable from year to year. Having gradually developed since the heroic age, runways have now grown to a length of about two miles . . . and belong in the discard.

But aviation also has more peaceful aspects . . . Who is better placed to write on "*Air Transport in A. D. 2005*" than *Peter G. Masefield,* Chief Executive of British European Airways? If a ballot were held on the "air transport man of the year", Peter Masefield would get my vote. During 1944 he has succeeded in making his airline, despite earlier weaknesses, into the most successful, from the point of view of technical equipment, in Europe. B.E.A. has the stubborn foresight of its Chief Executive and the *Dart* turboprop to thank for this. Yet Masefield can claim another title: as pupil and right hand man to the unforgettable C. G. Grey, and for many years editor of "The Aeroplane", he was in the front rank of *Interavia's* journalistic colleagues.—Air transport, he maintains, still must pursue the same six main goals: safety, speed, economy, reliability, comfort, range. He considers that not one of these goals, old as they are, has yet been reached. He, too, concludes that the basis of safety lies in a *change in the present take-off and landing methods.* Comfort? The best way to achieve this is through the "commodity which above all others, air transport has for sale", namely a *substantial increase in speed.* Why should speeds not reach, say, 3,000 m. p. h. during the next fifty years, even if this seems distinctly fantastic today? This would mean that any destination on earth could be reached within four hours, and would solve not only the question of economy but also many other air transport problems at the same time.

In order to get to this point, the "motorist" will have to turn away from the piston engine via the gas turbine to the atomic power plant. No one is more competent to speak on the solution to this problem than *John Jay Hopkins,* in whose plant the first vehicle with atomic power—though admittedly only a submarine—is already under construction. A brief word to non-American readers: John Jay Hopkins is boss of the *General Dynamics* group, to which not only the Electric Boat Co.—the submarine yards—but such leading aircraft firms as Convair and Canadair belong. Everybody knows that American industrialists do not lack imagination, but equally that they would not put one cent into fantastic adventures. Hopkins says literally: "I expect to see in my remaining lifetime fleets of commercial atomic passenger and cargo planes . . ." May he live long yet, though it must be admitted that he is already approaching sixty. So much optimism does us all good at the opening of 1955.

Among the articles on the next fifty years the reader will find a number on a new *configuration,* which its creator has christened the *coleopter.* Many may perhaps shake their heads when they see on the front cover a picture of an aircraft that is not yet flying. Nobody can swear that it will really be the coleopter which will revolutionize the world of aviation. Yet . . . Its designer, a first-rank rocket expert, and certainly no visionary, has succeeded in winning over leading industrialists to his ideas. *H. von Zborowski* has the kind of faith in his *annular-wing aircraft* which is said to be capable of moving mountains. The Editors took up the subject so as to illustrate the revolutionary ideas of an elite of research scientists by the revolutionary concept of apractical designer. They do not blindly subscribe to the idea of the coleopter in all its details, though they are convinced that only a revolutionary step can finally help aviation to grow up.

EEH.

Introductory Remarks

BY THEODORE VON KÁRMÁN

My good friend E.E.H. requested me to do some crystalball gazing for his journal concerning the next fifty years of aviation and the aeronautical sciences. My first objection was that some very competent people—for example, in the United States, the great designer of the first half-century, Glenn L. Martin, then Vice Admiral Emory S. Land, C. C. Furnas and finally Hugh L. Dryden[1] — had already published interesting predictions. Mr. Martin foresees airliners carrying 200 persons and keeping pace with the sun, finally achieving the dream of climbing up and waiting until the earth had turned to the place one wished to arrive at. I was especially impressed by Dr. Dryden's analysis of early predictions made before and during the first half century of human flight, which oscillate between Simon Newcomb's utterance in 1908: "The writer cannot see how anyone who carefully weighs all that he has said can avoid the conclusion that the era when we shall take the flyer as we now take the train belongs to dreamland", to Sir C. Richard Fairey's "Halfway Mark" (1931): "If we assume only that the present rate will be maintained for the next ten years, we can expect to see airplanes travelling at speeds of over 500 m.p.h., maintaining themselves for over 100 hours on the load they have lifted, and flying nearly 8,000 miles in a straight line non-stop". As far as the scope of possible applications of aircraft is concerned, it is interesting to read in Dr. Dryden's paper the quotation from an editorial which appeared in a 1908 issue of the *Engineering News:* "By no possibility can carriage of freight or passengers through mid-air compete with their carriage on the earth's surface. The field for aerial navigation is then limited to military use and for sporting purposes. The former is doubtful, the latter is fairly certain".

Then Dr. Dryden solves his own task in *The Next Fifty Years* in an admirable manner by relating the respective predictions of a fictitious Dr. Optimist, a Dr. Pessimist, and a Dr. Fence-Straddler. His remarks are very worthwhile reading.

My second objection was based on some personal experiences which make me very reluctant to take on the role of a prophet.

[1] Glenn L. Martin: Wright Brothers Lecture, 1953 *(I.A.S. Journal,* Feb. 1954). – Emory S. Land: Aviation Looks Ahead on its 50th Birthday *(National Geographic Magazine,* Dec. 1953.). – C. C. Furnas: Next Half Century *(Aeronautical Engineer's Review,* June 1953). – Hugh L. Dryden: Fact-finding for Tomorrow's Planes *(National Geographic Magazine,* Dec. 1953). – The Next Fifty Years *(Aero Digest,* July 1953).

At the Duisburg meeting of the German Society for the Aeronautical Sciences (Wissenschaftliche Gesellschaft für Luftfahrt): Professor Th. v. Kármán (right) and Professor G. Gabrielli (left).

A few years before the beginning of World War II, the U.S. Navy named a special committee to report on future possibilities of gas turbines in view of the needs of the Navy. The members of the committee included a number of the most prominent mechanical engineers in the country. The report suggested that the use of gas turbines for ships should be studied at once, but stated that gas turbines probably would not be used for aircraft propulsion in the foreseeable future because of their intrinsic high weight per horsepower. My face turns red when I remember that this report also bore my name, since it is common knowledge that the main argument for gas turbine propulsion of aircraft to-day is the extremely low weight of present gas turbines whereas their efficiency has not as yet reached that of piston engines. My only excuse is that I only attended the first meeting of the committee, at which I made a speech in favor of the gas turbine, and gave the authorization to the Chairman to sign my name without reading the report.

For these reasons I shall not attempt to make predictions of probable accomplishments of the next fifty years, but shall be satisfied if I can list some of the problems which aeronautical engineers and scientists will have to face.

*

At the beginning of this century the main problem was to do at least as well as a heavy soaring bird. In fact we find that the wing loading of the airplane of the Wright Brothers was between the wing loading of a vulture and an Australian crane. Also we find that the early pioneer of scientific aerodynamics, Charles Renard, concluded from studies of bird flight and some empirical air resistance measurements that in order to fly an airplane successfully the engine should not weigh more than 17 pounds per horsepower. The engine of the Wright Brothers had a weight per horsepower equal to 15 pounds per horsepower.

The scientific understanding of the mechanisms of lift and drag, which was accomplished by aerodynamic science when it became a branch of rational fluid mechanics, certainly had a decisive role in the spectacular progress made in airplane design in the past fifty years of mechanical flight. Of course the improvements in engine design and technology also were essential to the success. In the beginning progress was relatively easy, since even minor improvements in aerodynamics brought rich dividends. At that time we operated on what I would call the "descending branch" of the curve for specific power vs. speed. As a matter of fact, G. Gabrielli and the present writer showed that the transportation of an aircraft of the same weight over the same distance did not require additional horsepower hours when the speed was increased from 200 to 300 miles per hour. Further increase of speed had to be acquired by the use of more and more power and slowly the "motorist" became more important than the pure aerodynamicist.

One problem which necessitated careful aerodynamic design was the need to keep down as much as possible take-off and landing speeds. Nevertheless it appears that we have arrived at a point where a radical change has to be made in the philosophy of take-off and landing. In fact, the continuous increase of the length of runways makes the task facing the

people who run civil aviation more and more frustrating.

The enormous space requirement combined with the increasing noise nuisance drives airports further and further away from populated places. For cities near the sea, one may think of landing places filled up with water and the use of amphibia (Glenn L. Martin predicts the renaissance of flying boats). But also military aviation calls for a radical change of the take-off and landing process; for example, tactical air warfare should be as independent as possible of prepared runways. The new principle may be to separate the take-off and landing problem from the other performance requirements of the airplane by use of carriages, catapults, rocket assistance and the like, or is represented by various systems of vertical take-off, perhaps combined with methods of controlling the aircraft by jets instead of or in addition to aerodynamic control surfaces.

We are aware that everyone is watching present attempts to eliminate runways. I do not want to make any predictions about the competitive outlook for various VTO systems, the helicopter and the convertiplane. We find again that the possibility of success is closely connected with the question, how far the reduction of weight and the increase of efficiency of turbine engines can be pushed.

*

In classical low speed aerodynamics the compressibility of the air was neglected. As speeds increased, it became necessary to take compressibility into account. Aerodynamics has been extended to a new science, called—by a term introduced by G. A. Crocco—"Aerothermodynamics". When, in the coming years, piloted aircraft and missiles undertake the conquest of extremely high altitude, aerodynamics will have to include many elements of molecular gas theory, such as phenomena occurring in fluids of extremely low density. We enter a domain which we may call—using a term proposed by Albert F. Zahm—"Super-aerodynamics". Then vehicles may leave the atmosphere and the dynamics of a medium consisting of ionized gases which fill up the empty spaces will become an important subject for the designer. I, again, do not want to make predictions as to the future of space travel or "Astronautics", but it is highly probable that it may come to a trip to the moon, even if there is no other reason than the one expressed by the German humorist Moritz Busch for any kind of travel:

There are nice places far away,

Why at this place am I anyway.

However—as far as the problem of flight to extreme altitudes is concerned—the questions related to propulsion are again of extraordinary importance. Aerodynamics is, of course, also involved in the propulsion problems. We may proceed to a branch of science we may call "Aerothermochemistry". This science deals for example with questions of ignition and combustion in gas streams, combustion instability, inter-action between diffusion and chemical reaction and the like.

High speed in a dense atmosphere, as is unavoidable—for example, on the return trip from extreme altitudes—creates problems which may be covered by the term: "the battle against high temperatures". It is evident that in order to win this battle, aeronautical science and engineering should be extended to the problems of temperature stresses of materials resisting high temperature, to the questions of heat transfer, to specific methods of cooling and related questions. I cannot subscribe to the philosophy of the venerable Lord Brabazon who—according to press reports—declared at a hearing concerning the Comet accidents: "It was not *aeronautics* which failed, but *metallurgy*". In a naive way I would think that as long as we build aircraft of metal, metallurgy is a part of the Aeronautical Sciences. So are the branches of physics which teach us to understand the phenomena occurring at high altitudes such as radiation, dissociation and ionization, etc.

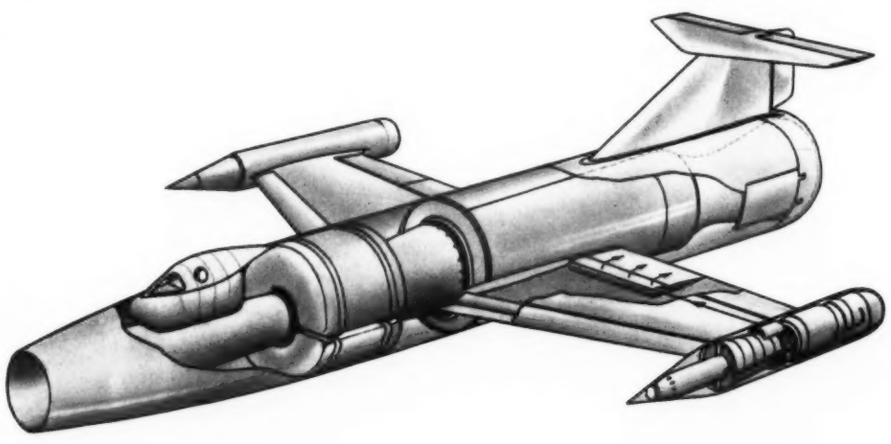
That the "motorist" again has a leading role in the realization of high speed, high altitude travel, is evident. I believe we are at the beginning of an era in which ramjets and rockets will be developed and perfected to an extent we find difficult to estimate today. I also believe that—after the spectacular reduction of the weight of turbojets—more attention will be given to the increase of their efficiency without making them too bulky or too heavy.

One certainly will study the development and application of novel high efficiency propellants and finally the replacement of chemical reactions by nuclear processes. We may remember that even in the case of present day propellants their energy per unit weight often cannot be fully utilized because of the limit set by the resistance of materials to high temperature.

I have to mention the problems related to guidance and automatic navigation. Some prophets foresee complete automatic control of airliners from the ground. As to military aircraft it cannot be denied that, for example, aiming of guns on aircraft flying at high supersonic speed may be beyond human capabilities. On the other hand, a famous test pilot of our days asked some technicians, protagonists of automatic brains: "Who is able to produce a non-linear servomotor with quick response and memory which does not weigh more than 150-160 pounds and can be made by completely unskilled labor?".

Necessarily—at least as far as air transportation between points on our globe is concerned—something will have to be invented to reduce the obnoxious noise of jet aircraft. Perhaps the effect of shockwaves will also be "regulated".

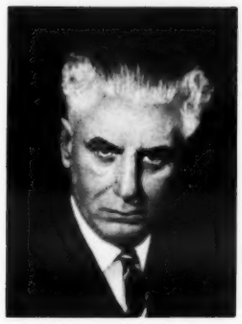
Finally, to comfort the pure aerodynamicist, I would like to mention one essentially fluid mechanics problem which has not been solved in true scientific fashion during the first fifty years of modern aerodynamics: the problem of turbulence. This problem may belong to the frontier between fluid mechanics and statistical theory. The great German theoretical physicist, the late Arthur Sommerfeld, told me many years ago that "he would like to understand two problems in theoretical physics before he died: the true meaning of quantum mechanics and the true mechanism of turbulance." I had no occasion to ask him whether he considered the present state of quantum mechanics—complementarity instead of causality—as fully satisfying. It is certain that the true understanding of turbulence has still to come in the next fifty years.



Supersonic ramjet aircraft for Mach 3, with auxiliary engines for subsonic flight. In fuselage, from front to back: diffusor for the ramjet engine (channel type); heat-insulated pressure cabin; pressurized fuel tanks (only the two forward tanks are shown); fuselage main bulkhead with fuel injector ring; fuselage rear with tail unit, air brakes and jet nozzle. The tips of the thin lens-shaped wing carry two high-power axial-compressor turbojets, which however are used only in subsonic flight, in particular for take-off and landing. In the two latter cases compressed air is bled off the compressors to blow off the boundary layer over the deflected rear flaps, thus improving lift coefficients (lower stalling speeds). The wing leading edge is of the "droop-snoot" variety. Before the turbojets are started up, their cowlings fold together to leave the air intake free. *Interavia drawing.*

Reaching for the Stars

BY PROF. GAETANO ARTURO CROCCO
FORMER INSPECTOR GENERAL OF THE ITALIAN AIR FORCE
AND PROFESSOR AT THE UNIVERSITY OF ROME



Despite the mists that shroud the next fifty years, I see for the end of the century and the millenium the achievement—not yet clear in outline—of the ultimate goal of applying jet reaction power to transport, namely, human travel, beyond the earth's atmosphere. This development will lead to the opening up of interplanetary routes. There are many, like me, who make this forecast, but many more who are sceptical. I therefore propose to devote this article to a recapitulation of the facts which support such a belief.

*

If the thin atmospheric layer which surrounds and protects our planet serves to sustain and feed today's gas turbine aircraft, it also creates problems of drag and friction heating, so that these aircraft are obliged to operate at greater and greater altitudes as their speed increases. The progress of aviation in this direction is not going to be slowed down by the unfortunate *Comet* episode. On the contrary, the latter will stimulate efforts towards the production of a cabin, perfect from the engineering point of view, with physiological conditions adapted to all altitudes including ultimately that at which there is a complete vacuum. It is therefore certain that civil jet aircraft will reach at high altitude the final limit of their advance towards supersonic speeds, a limit which will be around at least 2,500 m.p.h.

But another kind of reaction vehicle has been developed: it is capable of covering almost all its trajectory in a vacuum, thus avoiding sonic and thermal barriers. This amazing machine has already reached a speed of over 6,000 m.p.h. without crew, levelling off after a vertical climb of 250 miles.

It can therefore be said that over half of the problem just enunciated, that concerning the actual machine and its cabin, has been solved. All that is missing is man. We all know why man is today excluded from the above-mentioned device, which has been developed from the V2 and which I shall call the "ballistic vehicle". This device is at present designed for military uses, which necessitate its disintegration on reaching its target.

Our Western mentality cannot accept any other than radio-electric methods of control for such a purpose. Even for civil purposes, such as exploration of the upper atmosphere, it is still not possible to make use of man as an observer, since the basic problem of his protection during return to the ground has not yet been solved.

*

The ballistic vehicle is closely related to the artillery projectile in the sense that both receive their motion from impulsion and maintain their trajectory by inertia; this enables both to conquer the atmosphere. But the initial impulsion is communicated to the projectile by the almost instantaneous *action* of a propulsive charge outside itself, while the ballistic vehicle receives it from the *reaction* produced by the continued combustion of an internal charge. The ballistic vehicle therefore has the advantage of *progressive impulsion* which alone is compatible with the presence of man.

A second advantage stems from the intrinsic characteristic that the charge required to reach a given speed does not depend, other things being equal, on its own law of combustion, but that this combustion can be regulated so that acceleration is always physiologically tolerable.

A third advantage of the ballistic vehicle, unknown to the artillery shell, is the possibility of regulating en route the propulsive thrust produced by the combustion of the charge, i. e., of reducing or increasing it, cutting it off as required, restarting it if needed or diverting it in relation to the trajectory. The vehicle therefore has the same manoeuvring facilities as any other means of locomotion, including turning, braking and reversal of the direction of travel. Hence the space vehicle, capable of travelling beyond the atmosphere, will have the same manoeuvrability as machines moving inside the atmosphere.

*

Then there is a fourth advantage, exclusive to the space vehicle, namely the possibility of *adding together available impulsions.* This is a valuable advantage in the present state of development, as it extends the range of speeds obtainable despite the limited strength of the impulsions today obtainable. Two methods of taking advantage of this property have already been elaborated, that of *multi-stage propulsion,* and that of *refuelling in flight.*

*

To illustrate the principle, I shall describe the case of two consecutive impulsions obtained by two missiles.

In the *multi-stage method,* the vehicle to which all impulsions are successively communicated (the totalizer) remains *inactive* while subjected to the thrust from the propulsive rocket; the latter detaches itself as soon as it has completed its function. The totalizer then itself provides the subsequent impulsion.

In the *flight refuelling method* the totalizer is *permanently active;* that is, it alone supplies the two required impulsions, being refuelled meanwhile by the second element in the system, which I shall call a *tank.*

The two methods are equivalent as regards *consumption*; i. e., for the same total impulsion with external conditions and structural coefficients being equal, total consumption will be the same in both cases.

On the other hand, the two methods differ in the way in which the auxiliary elements return to the ground. In the case of multiple stages, which are coupled *in series,* only the totalizer at the head can be recovered intact. The auxiliary propulsive mechanisms are allowed to fall freely (or slowed down by braking) after they detach themselves from the whole assembly, without provision for landing. In the flight refuelling method, however, where the various elements are generally connected *in parallel,* both the totalizer and the auxiliary tanks are fitted with wings and can glide down like aircraft and land safely[1].

Model of a rocket bundle.

[1] *Jet Propulsion,* No. 5, September/October 1954.

Moreover, the capacity of each tank can be divided into smaller, more manageable units.

The multi-stage method is well known, and there is no need to illustrate it here. As mentioned above, an altitude of 250 miles has already been attained by a two-stage missile. Engineer von Braun has designed and calculated a heavy vehicle with three stages, the leading element in which will be capable of a speed of 18,000 m.p.h.[2]

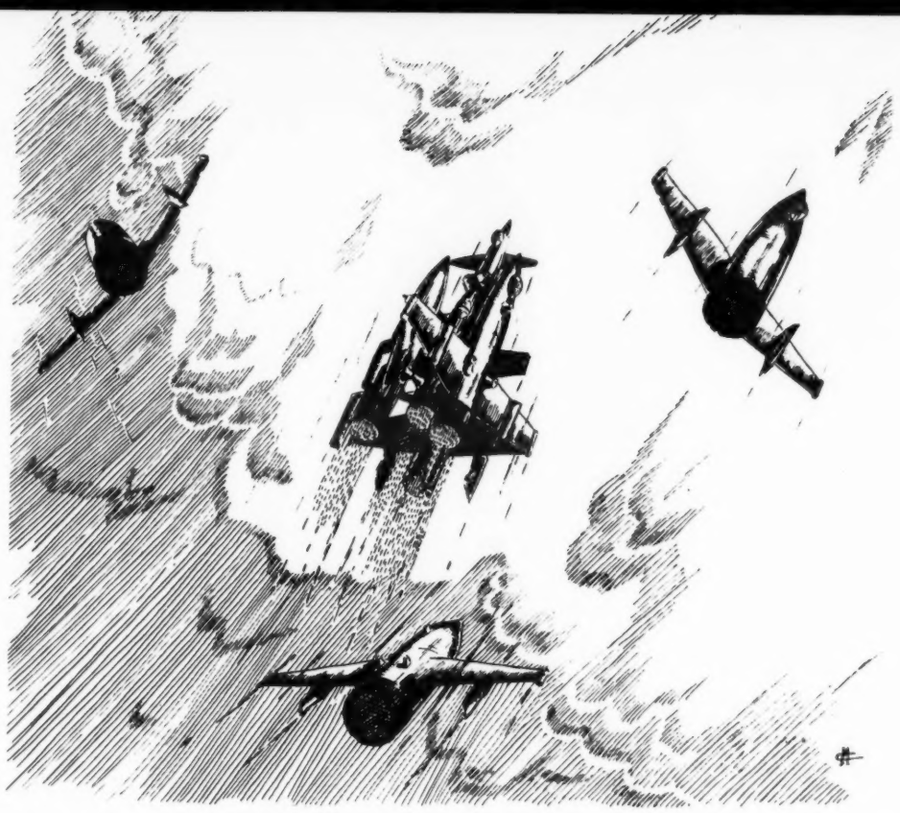
On the other hand, the method of continuous refuelling in flight is little known in its application to space vehicles, as it was discussed only at the Fourth International Astronautics Congress in Zurich in 1953, from which I have taken some of the special characteristics mentioned.[3] I am accompanying this article by a drawing showing the system of missiles in flight at the moment when the three tanks that have been used for the first refuelling are starting on the return journey, while the group of three tanks in parallel intended for the second refuelling continue on their route, along with the central tank for the third refuelling combined in series with the totalizer. The latter would total the same speed as the von Braun project. I am also attaching a photograph of the aerodynamic model, shown in flight shortly before the tanks break away.

It should be noted that the possibility of ensuring the safe return to the ground of the tanks forming the refuelling equipment is in no way essential to the technical result aimed at; but it becomes a structural necessity for ballistic vehicles designed for civilian uses, which require successive refuelling and impulsions after launching. Costs would be prohibitive if the whole auxiliary equipment had to be built anew each time. This auxiliary equipment must constitute the operating fleet of ballistic locomotion undertakings, in the same way as airlines today have their operating fleets.

*

Such then are the considerations in favour of the contention that human flight beyond the atmosphere is possible. The most important consideration against it is the fact that the ballistic vehicle must carry from the start the whole of the oxidizer it needs to sustain combustion, whereas the ordinary aircraft takes up its oxygen en route. Consequently consumption will appear very heavy by comparison, and it increases according to an exponential function of the aggregate speed.

It is at this point that a surprising peculiarity in connection with gravitation, due to the earth's rotundity, intervenes in the game of for and against. Let us imagine that a ballistic vehicle has been built, capable of covering the 10,000 miles between Rome and Melbourne. It would need only a slight increase in total speed to enable the vehicle, by a very simple manoeuvre, to lengthen its trajectory towards an *infinite multiple* of the terrestrial meridian. In other words, it would become a permanent artificial satellite to the earth.



Ballistic vehicle in flight, just after the first three tank units have broken away to return to the ground.

This problem has been under investigation for some years, and it was the subject of the Second International Congress in London. A number of ingenious projects have been worked out to show that solutions can be found in the present stage of technical development.

This possibility considerably enlarges the prospects of space travel. The orbit followed by a satellite vehicle several thousand miles beyond the atmosphere can be regarded as the threshold for access to a domain whose features differ considerably from those of atmospheric flight. On this side of this boundary, human space travel is of no interest, as already stated; beyond this limit, however, the immense, unknown interplanetary routes open out to man. And the laws of celestial mechanics enable him to enter them easily from this threshold. For this purpose the same satellite vehicle, suitably fuelled and equipped by means of tanks launched from the earth and capable of tying up to the vehicle, could be used. The satellite would then be able to acquire sufficient speed to escape from the field of the earth's attraction and reach an orbit round the *sun,* more extensive than that about the earth, so that it passes close to the orbit of another planet. This would initiate the conquest of space.

*

Will all this really happen? There is a fundamental syllogism which defines the attitude of the human mind: nothing that is technically possible will remain untried, especially as the economic problems are here outweighed by the lure of the unknown.

It will perhaps be asked why, if it seems possible to conquer interplanetary space, it should be expected to take another fifty years.

The reason is that there is a very real obstacle to this undertaking. Namely, it is impossible to send man outside the earth's atmosphere on the material conquest of space without having first completed its intellectual conquest; i. e., without having studied and solved the problem in all its aspects. Contrary factors are involved which will have to be eliminated by operations without risk.

Astronautics is still in the theoretical stage; the problem of the return to earth has not yet been solved; study of the physiological behaviour of man during a voyage in space has scarcely begun; the possibility of using radar for great celestial journeys is still only a hypothesis; the chemistry of combustion in multi-reactor or mono-reactor systems is still under study by thermodynamicists and laboratory experts; moreover the so-called absolute vacuum is actually full of meteorites, which would pierce the cabin, and of cosmic rays which would attack the human body despite all imaginable protection and thus threaten the safety of journeys as long as those under discussion.

All this will be ample to occupy the next fifty years, unless nuclear energy can reduce the number of impulsions necessary and make possible much shorter journeys.

But my present premises do not enable me to make any forecast of when this may be.

[2] *Colliers,* March 22nd, 1952.

[3] Report on the Congress, to be published shortly by Laubscher, Bienne, Switzerland.

"Castles in the Air" at the Turn of the Century

Prophesying is more dangerous than tight-rope walking, and Hemingway's scepticism was well founded when he was recently asked for a forecast of the next fifty years. Half a century! he exclaimed. It was all he could do to imagine what might happen next week.

Admittedly geniuses like Nostradamus can handle a thousand years as if it were a trifle. Besides the other advantages and inconveniences of the twentieth century Nostradamus also, of course, foresaw the advent of air transport down to the exact minute. "On the 326th passage of the planet Mars", he said "when the Northern realm and the Southern realm will have twice come into bloody conflict, chariots will travel roaring through the air. Men will wait for these chariots, as they now wait for ships in the harbours . . ." As far as the waiting is concerned, Nostradamus certainly hit the bull's eye.

But leaving aside such specially favoured seers, the ordinary mortal gets little joy out of prophesying. Yet he cannot leave it alone. Charwomen, finance ministers, military chiefs, university professors, capitalists, revolutionaries faithful to the party line . . . there is no profession, no class of society, no cult or sect that is proof against the lure of prophecy.

*

There is no want of ability among the prophets. At times they have forecast with astonishing accuracy. But there have also been some real misfires that have found their way into the most clairvoyant of prophecies.

Even the most practised professionals occasionally come a cropper. One example is H. G. Wells, who early in the twentieth century accurately and fully forecast what mankind would do in the second half of the century. Author of "The First Men in the Moon," "The War in the Air," "The Stolen Bacillus," "The Time Machine," "The War of the Worlds," etc., Wells by no means contented himself with fantastic romances, but knew how to deal seriously with his subject and to initiate his contemporaries into the highest and last things. In 1901 he published an essay entitled "Anticipations of the Reaction of Mechanical and Scientific Progress upon Human Life and Thought."

In this booklet he gives—twenty years before Douhet—a complete definition of "aerial supremacy," such as military scientists might envy him:

". . . Once the command of the air is obtained by one of the contending armies (wrote Wells in 1901!), the war must become a conflict between a seeing host and one that is blind. The victor in that aerial struggle . . . will mark all his adversary's roads and communications, and sweep them with sudden incredible disasters of shot and shell. The moral effect of this predominance will be enormous. . . . Everybody everywhere will be perpetually and constantly looking up, with a sense of loss and insecurity . . ."

Clairvoyant, without a doubt. But in the first chapter of the same book, in which Wells talks at considerable length on future means of locomotion, air transport is given only the following sceptical footnote:

"I have said nothing in this chapter, devoted to locomotion, of the coming invention of flying. This is from no disbelief in its final practicability, nor from any disregard of the new influences it will bring to bear upon mankind. But I do not think it at all probable that aeronautics will ever come into play as a serious modification of transport and communication . . . Man is not an albatross, but a land biped . . ."

*

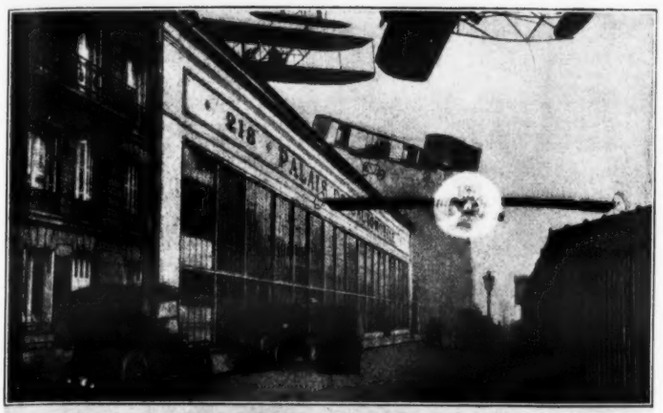
If H. G. Wells has been cited first, this does not mean that the British had any monopoly on visions of the future. On the contrary. France too produced its share of prophecies at the turn of the century. Apart from Jules Verne, the classic example, there was an impressive amount of literature, which today fills several shelves in the Paris Air Museum and whose creations have no match today even in the most successful drawing offices.

Do not imagine that "flying saucers" are a product of our generation. They can be seen in black and white, flying and landing, in Pierre Giffard's "La Guerre Infernale", a two-volume forecast of the world wars published by Méricant, Paris in 1908 and illustrated by the prolific draughtsman A. Robida. These "flying bodies" (see picture) are described with an exactitude in no way inferior to that of the American flying saucer literature of 1950-54:

"Nobody can describe the exact dimensions or the nationality of this mysterious aerocar, which approaches at such astounding performance . . . The machine in question is a black shape resembling the shell of a huge tortoise. But its speed is such that the eye has no time to take in its exact shape. Some even claim that the shape changes with the circumstances.

Flying saucer in flight, from "La Guerre Infernale" by P. Giffard, published in 1908.

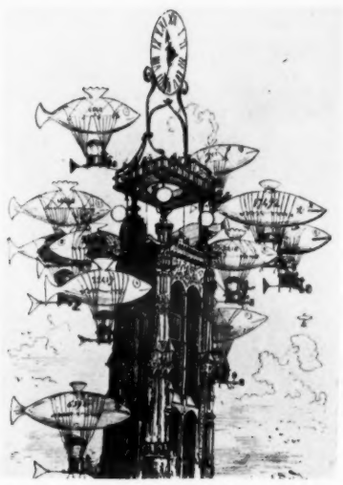
Flying saucer after landing.



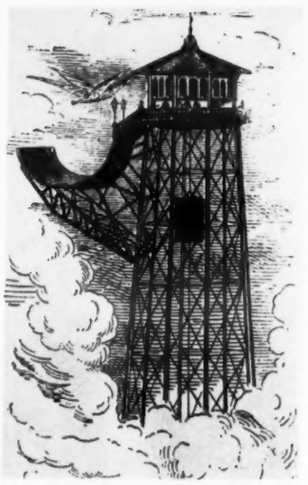
CE QUE SERONT DANS DIX ANS LES GARAGES D'AUJOURD'HUI

Dans dix ans, les garages d'automobiles seront obligés d'aménager leur toit de façon à y loger les aéroplanes. MM. Maurice Farman et Neubauer, directeurs du Palais de l'Automobile, y ont déjà songé et c'est ainsi que sera... peut-être bientôt, le colossal établissement du boulevard Péreire.

A Paris airport on the roof of the Farman garage. Drawing from "Je sais tout" of April 15th, 1909.



Paris airport on the Saint-Jacques tower. Drawing by A. Robida in "Vingtième Siècle" (1884).



New York airport. Project from the "Daily Graphic," April 1st, 1880.

Without engaging in fantastic speculations, it is possible to say that the mysterious machine is actuated by a new force; it sends out sudden flashes against the dark sky, either purposely or otherwise."

*

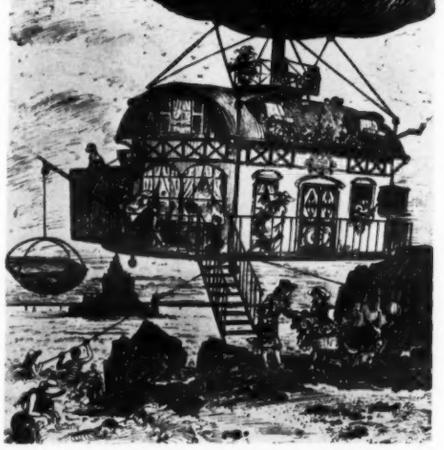
Air transport comes into its own in an interview between the inventor Thomas Alva Edison and a reporter from the New York "Daily Graphic," which the magazine "l'Aéronaute" of June 1880 reproduced in French. The title alone is a programme . . . and not such a stupid one either: "Mr. Edison's Latest Triumph; How to Fly from New York to Moscow in 24 hours."

The American interviewer may be pardoned for not foreseeing the Iron Curtain. But otherwise he gets all the details out of Edison. From the flight of birds to the establishment of the first air transport company "The Universal Aerial Navigation Company of the United States" (capital $ 10,000,000), he draws out all the secrets, with the exception of the small matter of propulsion power—a subject which still presents certain riddles today. When asked whether he would use a steam engine, an electric battery or compressed air, Edison replied with a cunning smile: "You can call it what you will; in any case I shall install it in my air ship. It will move the wings and weigh a great deal less than a steam engine or a battery."

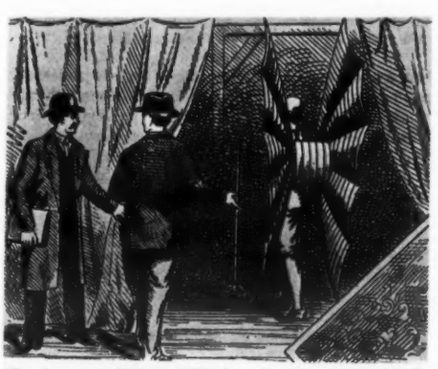
So said Edison in 1880 . . .

*

Ideas on the airport in 1900 presented a much more practical and less cumbersome solution than the "tape-worm" runways of 1954, which to the despair of all concerned seem to be stretching to endless lengths. The ideal airport, it was agreed, should be on a steel framework, on the roof or in the cellar. On the subject of the roof site "Je Sais Tout" of April 15th, 1909, turns to Maurice Farman and states: "Maurice Farman and Neubauer,



The "aero chalet," suspended from a balloon; drawing by A. Robida.



The inventor Edison initiating the New York "Daily Graphic" reporter into his latest secret.

Flying Alpine Unit's hangar in the rock ("La Guerre Infernale" 1908) . . . Note the unit leader's trumpet.

the charming managers of the Palais de l'Automobile, have given the matter considerable thought and decided they could open the roof of their garage to the new means of locomotion . . . In a few days everything could be ready." . . . In a few days . . .

*

The most ingenious forecast, however, comes from a humorist, Henry Kistemaeckers. In his "Aéropolis" published in 1909 guying the nascent air age, he clearly foretold the breakdowns, repairs and delays on the ground. He buys an aeroplane and flies from Paris to Nice. His diary of the journey opens as follows:

"November 17th.—I've got my aeroplane! 20,000 francs. A pretty sum. But by all accounts a perfect machine! You can fly it in white gloves, yes sir!"

To cut a long story short, the white gloves get blacker and blacker when he has to stop at every village smithy for engine, aircraft or propeller repairs. The last entry in the diary says:

"January 20th—Nice. My charming aeroplane has just arrived. It left Paris on November 20th. It got to Nice on January 20th. Sixty days for this distance. So what? I hold the record for Paris-Nice, slow-speed category, that's all."

*

Incidentally are you interested in a 100% reliable forecast for the year 2000?

Mark our words, *there'll still be trouble in the world!*

Long-Range Commercial Transports of the Coming Decade

Even though certain leading representatives of United States and British industry still forecast a long and successful career for the long-range commercial transports with piston or compound engines now in service or under construction, it is clear that the next ten to fifteen years will see the advent of regular air service by turbine-powered models[1]. The development principles for these aircraft are based on the target of cruising speeds of 400 to 450 m. p. h. and sufficient range for non-stop flight between the United States and Europe.

Towards the end of last year the two main suppliers of long-range commercial transports, *Lockheed Aircraft Corporation*, Burbank, California, and *Douglas Aircraft Company*, of Santa Monica, California, published details of two projected turboprop transports, the *Lockheed L-1449 Super Constellation* and the *Douglas DC-7D*. Both developments of proven models, they are to be ready for airline operation by 1957–58. The appeal of these newest members of Lockheed's *Super Constellation* and Douglas's DC families is witnessed by the fact that even B. O. A. C. — despite heated criticism by Parliament and industry — is discussing the purchase of 15 Douglas DC-7Ds. Other airlines, such as T. W. A., seem to be seriously considering ordering the Lockheed L-1449.

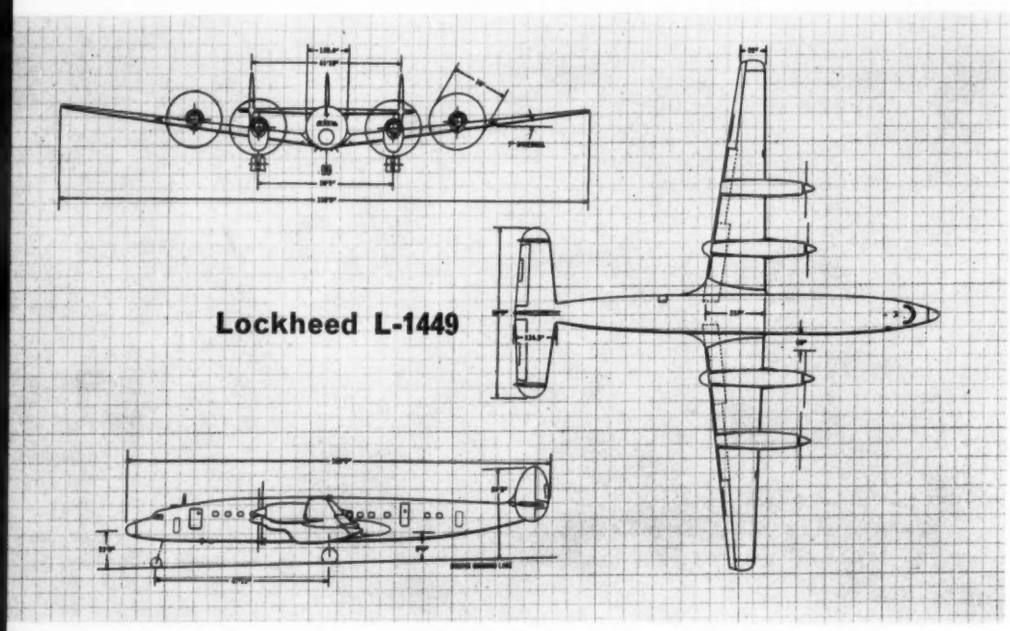
[1] Cf. *Interavia* Review of World Aviation, No. 6, 1954

Thin wing for the L-1449

To make best use of the advantages of turboprops—namely speed—Lockheed found that in the L-1449, they were obliged to abandon the well-tried wing configuration of the *Constellation* and *Super Constellation*. The L-1449 will therefore have a newly designed wing of larger aspect ratio (approx. 12) and smaller thickness-chord ratio than its predecessors. Span will be 27 ft. longer and wing area 206 sq. ft. greater. Other features of the new wing are more efficient landing flaps and thermal deicing. The fuselage of the L-1449 will also be 55 inches longer than that of its immediate predecessor. The cabin—at present designed for first-class service only—will cary 64 passengers on overseas routes and 70 passengers on American domestic routes.

Power plant

The turboprop models to be used for the DC-7D and L-1449 are the subject of widespread guessing. Some circles seem to regard the British RB.109 propeller turbine as a certain choice for the Douglas model, though this is, in fact, merely one of several projects. The final decision would appear not to have been made yet. Lockheed plans to fit its L-1449 with four Pratt & Whitney PT-2 turboprops of approx. 6,000 e. h. p. each. This is the engine whose military version (T-34) is used, for example, in the U. S. Navy's R7V-2 radar early warning aircraft.



Technical data for the Lockheed L-1449

Power plant: Four Pratt & Whitney PT-2 (T-34) of approx. 6,000 e.h.p. each. Hamilton Standard three-blade propellers; diameter 16 ft.

Main dimensions and weights:

Span	150 ft.
Wing chord at root	217 ins.
at tips	82 ins.
Length	120 ft. 9 ins.
Operational weight empty,	
U.S. domestic traffic	88,700 lbs.
Intercontinental	90 400 lbs.
Max. take-off weight	175,000 lbs.
Max. landing weight	123,000 lbs.

Performance

At gross weight of	123,000 lbs.	150,000 lbs.
Max. level speed	436 m.p.h.	432 m.p.h.
at rated power and altitude of	20,000 ft.	20,000 ft.
Level speed	421 m.p.h.	410 m.p.h.
at max. cruising power and altitude of	30,000 ft.	30,000 ft.
Stalling speed during landing approach	101 m.p.h.	—
Max. rate of climb, 4 engines		
at sea level	3,470 ft/min	2,850 ft/min
at 30,000 ft.	1,090 ft/min	650 ft/min
Service ceiling, 4 engines	35,700 ft.	28,400 ft.
3 engines	30,000 ft.	22,900 ft.
C.A.A. runway length, take-off	—	4,080 ft.
landing	5,820 ft.	—

C.A.A. runway length, take-off with max. gross weight 5,810 ft.

Subscriptions for yourself and your friends

will make sure that you get your copies of "INTERAVIA Review" regularly every month. Just fill out the enclosed order card and send it to Interavia's nearest agent or to your bookseller

Representatives :

Austria	Interavia, Postfach 162, Vienna I.
Belgium	Interavia, 5, Heidestraat Noord, Cappellenbosch-lez-Anvers.
Canada	Interavia, 21, Hargrove Lane, Toronto 14, Ont.
France	Interavia, 144, Avenue des Champs-Elysées, Paris 8me.
Germany	Interavia Verlags G.m.b.H., Friedrich Ebert-Strasse 1, Frankfurt/M.
Great Britain	Interavia (U.K.) Ltd., 27, Old Bond Street, London, W. 1.
Holland	Henk A. Jansen, Olympiaplein 84, Amsterdam-Z.
Italy	Interavia, 30, Via San Marino, Rome 7.23.
South Africa	Interavia, P.O. Box 6073, Johannesburg.
Spain	Interavia, Donoso Cortés 85, Madrid.
Sweden	Interavia, P. O. Box 29, Linköping
Switzerland	Interavia, Corraterie 6, Geneva.
U.S.A.	Interavia, Head Office : 123 N. Gladys Ave., Monterey Park, Calif. Branch Office : 185 Madison Ave., New York 16, N.Y.

SUBSCRIPTION PRICES

Countries	12 months	Currency	6 months	Countries	12 months	Currency	6 months
Austria . . .	170.—	Sch.	90.—	Netherlands	25.—	H. fl.	13.—
Belgium . .	320.—	Fr. b.	170.—	Spain. . . .	280.—	Pts	145.—
Canada * . .	7.00	U.S.$	4.00	Sweden . .	35.—	Kr.	18.—
France . . .	2400.—	Fr. fr.	1300.—	Switzerland .	28.—	Fr. s.	15.—
Germany . .	27.50	DM	14.50	Union of			
Great Britain	1. 15. 0	£	1. 0. 0	South Africa	2. 6. 0	£	1. 5. 0
Italy	4060.—	L. it.	2175.—	U.S.A.*. . .	7.00	$	4.00
Japan *. . .	7.00	U.S.$	4.00				

* two years 12 $

Please enter my subscription **INTERAVIA** in English/French/German/Spanish * for ☐ 1 year ☐ 2 years ☐ 6 months

beginning with issue _____/19____

Subscription fee _____ ☐ Check enclosed ☐ Please bill

Name : ** _____

Address : _____

Profession : _____

Employer : _____

For gift subscriptions :

This subscription has been ordered by :

Name : ** _____

Address : _____

Signature _____ Date _____

* Please check language desired. ** Please write in block letters.

INTERAVIA

Review of World aviation

INTERAVIA
REVIEW OF WORLD AVIATION

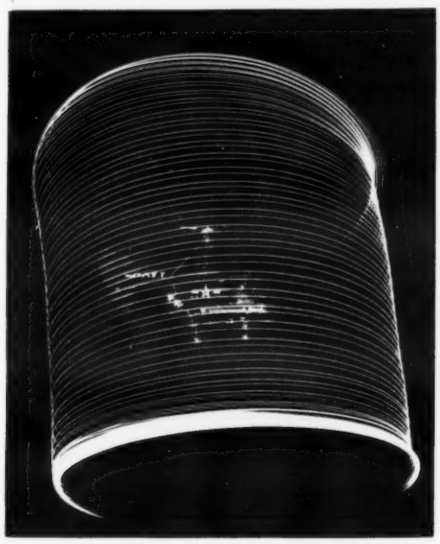
Please fill in the address

V. T. O.
Chronicle of a Technical Revolution

Vertical take-off machines are the outcome of a centuries-old idea in engineering. The historian could point to Leonardo da Vinci's concept of a "lifting airscrew", though the engineer will probably be satisfied to begin with the first manned helicopters by *Bréguet* and *Cornu* and to end with the *Convair* and *Lockheed* vertical risers. However, the use of rotary-wing or propeller thrust is only one way of providing vertical climb and descent. Other prospects are opened up by the jet thrusts of rockets or turbojets, or even — as S.N.E.C.M.A. has proved—of pulse-et engines.

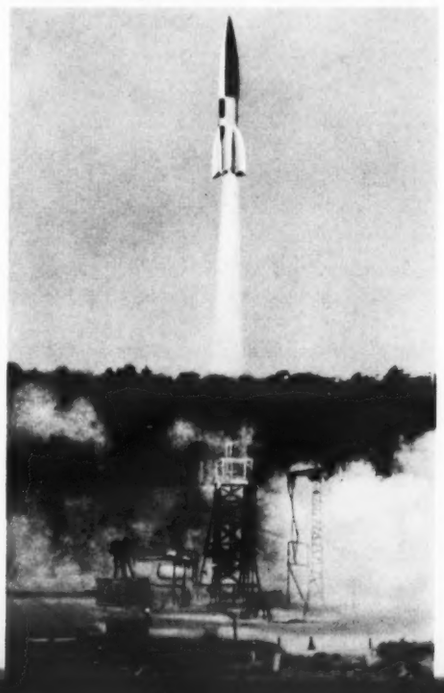
This possibility of using the thrust of lightweight gas turbines direct for vertical take-off has made engineers and military experts throughout the world prick up their ears. In the United States, *Ryan* and *Bell* are working—in strictest secrecy—on V.T.O. machines with jet power. In Canada, *Avro Canada* designed a kind of "flying saucer". In Britain, *Rolls-Royce* have made the experimental *Flying Bedstead*, and *Fairey* have been experimenting for several years on V.T.O. methods for their turbojet and rocket deltas. Finally, in France, S.N.E.C.M.A. and B.T.Z. are working on "flying jet engines" with and without annular wings.

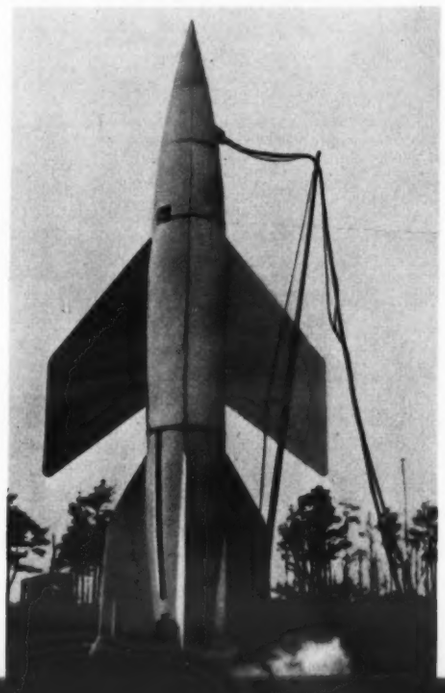
Rotary-wing Aircraft in the form of helicopters, gyrodynes and convertible aircraft —whether powered by piston engines or gas turbines—will play an important part in aviation during the next fifty years, particularly in short-stage traffic and in service aviation. In addition to medium-size helicopters—Sikorsky, Bell, Hiller, Piasecki, Kaman, Bristol, Saunders Roe, Fairey, Hunting-Percival, Westland, S.N.C.A.S.O., S.N.C.A.S.E. etc.—there are today large helicopters (Hughes) and midget helicopters (Hiller, SaundersRoe, S.N.C.A.S.O.). Development of compound helicopters (e.g. Fairey) and convertible aircraft (e.g., Convertawings) is in progress.—However, rotary-wing aircraft are today meeting a dangerous rival in the jet-powered V.T.O. machine. Pictures on this page show a night departure (left) and a night landing (right) by a *Kaman HTK-1* helicopter, with lights mounted at the rotor tips. (Additional flash light was used to catch the helicopter itself).

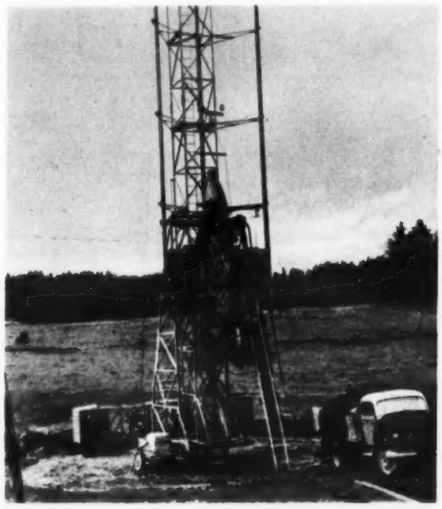


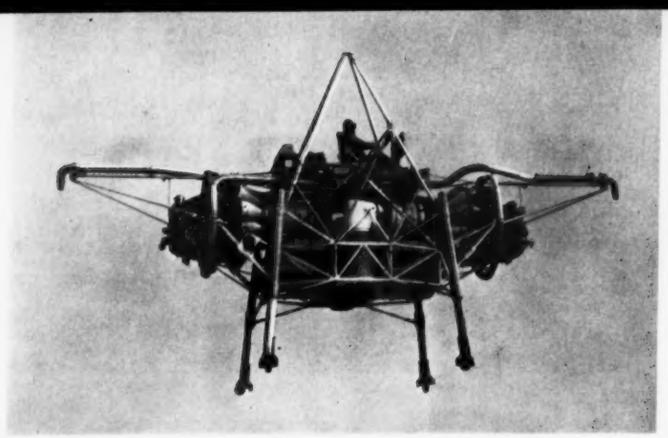
Long-range rockets of the A4 V2 type were first launched experimentally at Peenemünde, Germany (picture) in the late autumn of 1942 and were used operationally from the summer of 1944. With a gross launching weight of approx. 28,600 lbs. (including 19,200 lbs. of propellant), the A4's initial thrust was approx. 55,100 lbs., rising to 63,900 lbs. at higher altitude. Maximum ceiling of the military rocket was 56 miles, and range about 185 miles. Steering was provided by jet vanes and aerodynamic surfaces, both in conjunction with an automatic control system.—*Winged long-range rockets* of the A4b type (right-hand picture) of the same thrust but slightly higher take-off weight were merely fired experimentally at Peenemünde—two in all. They were expected to have a range of about 370 miles.

V.T.O. Rocket Fighters (Bachem BP.20 *Natter*) were built and tested in South Germany towards the end of the war. Take-off weight 4,630 lbs., main rocket thrust 3,850 lbs., additional rocket thrust 4×2,645 lbs.; jet vanes; aerodynamic control surfaces.—Only one manned take-off was completed (it killed the pilot) but several pilotless ascents were made.

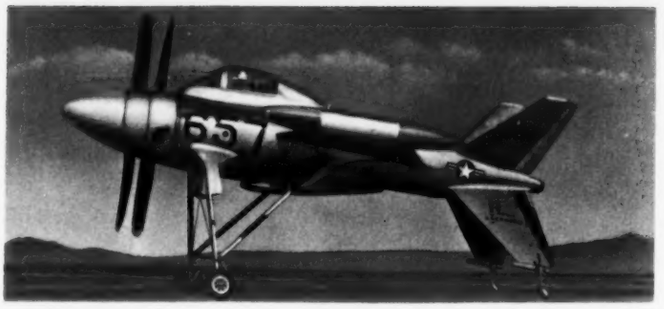






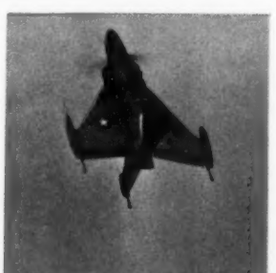


An experimental V. T. O. device, the Rolls-Royce *Flying Bedstead,* made its first free flight on August 3rd, 1954. It is actuated by two Rolls-Royce *Nene* turbojets (with jet pipes bent downwards) and steered by four compressed air nozzles on outriggers, by means of an ordinary control column and pedals from the pilot's seat.



Horizontal tests have been made since the summer of 1954 by the Lockheed XFV-1 vertical riser, with a dual Allison T-40 propeller turbine. In the autumn of 1954 vertical hovering and transition tests were made at altitude, and first vertical take-off experiments may be expected shortly.

Preparing vertical take-off for the Lockheed XFV-1: A tractor (extreme left, outside the picture) pushes the XFV-1 on its auxiliary undercarriage into the mobile hoisting framework. After removal of the auxiliary undercarriage the XFV-1 is lifted into the vertical position and the framework moved away; the aircraft rests on four oleo legs attached to the cruciform tail.



First real transition flights—free vertical take-offs followed by horizontal flight and vertical landing—were made by the Convair XFY-1 *Pogo* at Brownfield, near San Diego, California on November 2nd and 4th, 1954. The second flight was made before 200 press representatives. The *Pogo* turned from the vertical into the horizontal at a height of about 100 ft., the process taking only about 17 seconds (excluding the time required for take-off and climb). After a brief flight, the aircraft was again "hung on its propellers" and gently lowered to the ground, tail first, exactly at its take-off point.—The Convair XFY-1, too, is fitted with a twin-turbine Allison T-40 turboprop (5,840 e.h.p.) and contra-rotating propellers, but unlike the Lockheed design has a delta wing, so that the tail unit could be simplified. Test Pilot J. F. "Skeets" Coleman said after the flight: "It's the smoothest airplane I ever flew. It handles like a dream."

S.N.E.C.M.A. and Vertical Take-off

BY HENRI DESBRUÈRES
CHAIRMAN, SOCIÉTÉ NATIONALE D'ÉTUDE ET DE CONSTRUCTION
DE MOTEURS D'AVIATION, PARIS

Born on April 15th, 1907, the author attended the Ecole Polytechnique. He joined the French Air Force, gradually rising to the rank of Air Engineer General. From 1945 to 1948 he acted as Managing Director to Air France, and in 1949 was appointed Chairman of the Government-controlled S.N.E.C.M.A. aircraft engine concern (formerly Gnôme & Rhône), then struggling to overcome post-war difficulties. The successful reorganization of France's largest engine firm is due to his efforts.

Ever since the birth of flying, aeronautical engineers have been possessed with the idea of vertical take-off and landing.

What has hitherto been no more than a deep-seated desire to overcome the laws of gravity has now become, suddenly and tragically, an immediate necessity, in order to meet the crushing menace of the atomic weapon in the tactical and strategic fields. We are therefore faced with the urgent need to solve this problem of vertical take-off and landing while retaining all the advantages of the aircraft performance already achieved, or even improving it, since otherwise its efficiency would be dangerously reduced in the first hours of an attack.

To meet these new requirements S.N.E.C.M.A. has selected the aircraft category known as the coleopter, in which the engine becomes the primary element. This is not a convertible aircraft, but actually a *flying engine*.

We are here entering on an entirely new line of technical development whose full future scope cannot yet be divined.

The Coleopter

A Formula for Economy

BY DIPL. ING. HELMUT VON ZBOROWSKI,
B.T.Z., BRUNOY (FRANCE)

Born in Theresienstadt (at that time Austria) on August 21st, 1905, the author studied mechanical engineering at Graz Technical University, graduating as Diplom-Ingenieur. In 1934 he joined B.M.W. in Munich, then transferred two years later to the Brunswick Aeronautical Research Institute. Later he returned to B.M.W. and was entrusted with the development of special power plants, in particular rocket engines.—In 1948 Zborowski moved to France and resumed his work on rocket engines, this time for Société d'Etude de la Propulsion par Réaction. Later he founded his own business, the Bureau Technique Zborowski, whose object is to develop new aircraft and missile configurations and which has certain affiliations with the S.N.E.C.M.A. engine firm.

Yesterday and tomorrow

The first half century of powered flight began with the "heroic" age of the aviation pioneers. At that time the sole object was to "fly"; then the urge became to fly faster, higher, farther and more comfortably. And during the last third of this period the need to consider economy has become increasingly marked.

There is thus one point on which forecasts for the next fifty years can be certain: *this period will be dominated by economic considerations.*

If it is remembered that the only true yardstick throughout all technical progress is economy, that in general a mechanism is described as better or worse according to whether it requires smaller or greater expenditure to achieve a given effect, such a forecast may be regarded as a platitude. But if we ask what this more economical aircraft will look like, it is difficult, even for the expert, to get at really clear lines of development.

*

Before giving my view of these lines, I should like quickly to run over the recent past to show what attempts have already been made at improving economy:

— "*derefinement*", due to wartime shortages of labour and material. A good example is the He 162 "People's Fighter" *(fig. 1)*;

— *reducing costs through lightweight construction;* the classical example of recent times is the Folland *Gnat*;

— *reducing actual production costs per lb. structural weight,* which leads to the concept of the short-life aircraft. (The sound aspects of this technique are covered by the above two concepts of "derefinement" and "lightweight construction.");

— *better choice of power plant.* Attempts to reduce costs through the power plant were

Fig. 1: Germany's Heinkel He 162 "People's Fighter," designed at the end of 1944, is a prime example of "derefinement" and "lightweight construction".

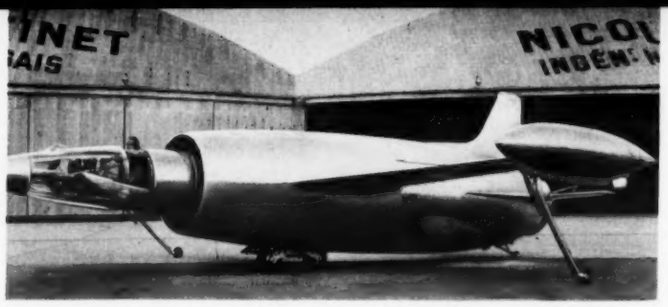


Fig. 2: "Suitable power plant choice" is the characteristic feature of the Leduc 021 ramjet subsonic research aircraft.

made by Junkers and Dornier in the Ju 86 and Do 18, both using diesel engines, Leduc *(fig. 2)* using a ramjet engine, Lippisch with his rocket-powered Me 163 and the Messerschmitt works with their Me 262 HS "Heimatschützer" combining jet engine and rocket. More recent examples are S.N.C.A.S.O.'s SO.6026 *Espadon* and SO. 9000 *Trident*;

— attempts at a more economical aircraft through *aerodynamic development* have been made by Hurel-Dubois with their wing of very high aspect ratio *(fig. 3)*;

— *to reduce the cost of runways,* a powered take-off trolley, jettisoned by the aircraft, has been designed. Example of this method is the S.N.C.A.S.E. *Baroudeur,* latest brain-child of the well-known designer Jakimiuk.

— finally mention should be made of the numerous *projects of aircraft to be independent of elaborate ground bases.* These save the cost not only of runways but also of airport installations. They include the helicopter, which has now been in service for some years, the Convair *(fig. 4)* and Lockheed "tail-sitters", and the various convertible aircraft.

*

Even this brief review is enough to scare the expert off any serious prophecies about the future of aircraft engineering, especially as each of these configurations can be fitted with any form of engine or any combination of engines; powder or liquid rockets, ramjets, turbojets or turboprops, spark-ignited or diesel engines, or even atomic power plants.

Towards the optimum solution

Yet the answer to the quest for the most economical aircraft is surprisingly simple if the whole is regarded as a unit, as a single fluid flow machine. The task then becomes one of finding the best overall design for this unit.

To arrive at the technically optimum machine there are just three basic laws that must be observed, uncompromisingly and simultaneously:

— choice of the most suitable procedure;

— use of the most suitable power plant;

— best possible matching of power plant and airframe.

Choosing the most suitable procedure: As we are here dealing with a limited sector of engineering—namely aeronautical engineering—choice among the various main procedures such as ground travel, projection through the air, flying is given from the beginning. Choice of procedure is therefore limited to special questions connected with flying, such as the method of take-off and landing, whether there is to be a crew or not, whether an expendable machine or one suitable for repeated utilization is required, and the choice of speed, altitude and rate of climb.

It must unfortunately be admitted that very few of these features can be fixed at the outset of a given task. They take shape gradually once the power plant has been decided upon.

Choice of the power plant: A first indication of the most suitable power plant for a given task can be obtained by plotting its impulse weight, i. e. by determining the proportion of total weight of propulsive unit to thrust times operating time (grammes/kg.t × sec).

As the impulse weight depends on speed and density—i. e., on altitude, for flight within the atmosphere—and also on the engine power, a series of tables should be prepared and kept up to date.

Fig. 5 shows a diagram of the impulse weight on the one hand for zero speed and zero altitude (bottom), and on the other for a speed corresponding to Mach 0.7 at an altitude of 6 km (top). The symbols used in the top diagram represent, from top to bottom: rocket engine, Lorin engine (ramjet), ducted propeller turbine, turbojet. As will be seen, each category of power plant can be allocated to a certain sphere, defined by operating times, in which it is superior to all other categories.

If the problem were merely to obtain optimum economy for a given speed, altitude and flying time, it would be easy to pick the only suitable power plant. For example, the diagram of impulse weight in *fig. 5* shows that for M = 0.7 and H = 6 km for a flying time of 1 hour, by far the most suitable engine is the turbojet.

If, however, the final aim is not fully defined; if for example all that is known is a given transport performance over a given distance, with speed, flying time and altitude left open, the technical optimum can only be obtained step by step. In the course of this process the parameters of speed and altitude will be ascertained and then, as a last step, the category of power plant. Similar steps will lead to the other unknown features, such as mode of take-off, rate of climb etc., which also ultimately affect the choice of engine or engine combination.

Matching power plant and airframe: Once the engine or engine combination is determined, it must be matched in the best possible way to its airframe. The whole machine and its

Fig 3.: Hurel-Dubois's high aspect ratio aircraft are examples of the attempt to obtain more economic configurations by aerodynamic means. Here the new HD 32, with modified rudder unit.

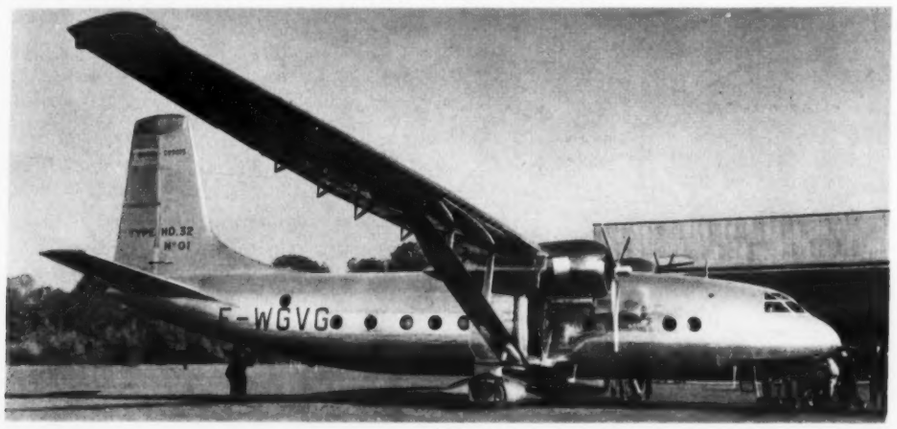


Fig. 4: The Convair XFY-1 *Pogo* "tail-sitter" is a configuration independent of airfields.

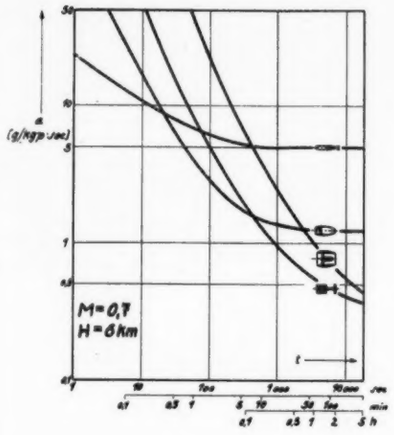
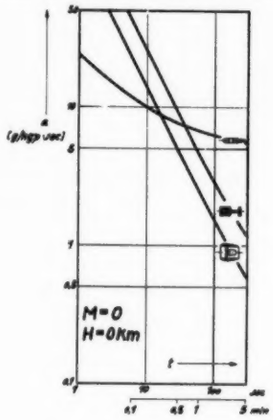


Fig. 5: Specific propulsion weights (in grammes per kg thrust and second) for various categories of power plant.



power plant must form one organic unit. The art of the design engineer will therefore be to make one and the same component serve a variety of purposes. This point is illustrated in *figs. 6 and 7*, which compare two different solutions for the same military requirements, both using a ramjet engine, the most suitable power plant for the given task. *Fig. 6* shows the *classic combination* of hollow charge, airframe and engine, as used with good results in the U.S. Navy's *Gorgon* guided missile. *Fig. 7* is a diagram of the *optimum weapons solution* for the same task, in the form of B.T.Z.'s *Ogre*.

Fig. 7 shows (top, centre) the airframe designed as a flying wing, in the form of an annular wing adapted to the power plant. Top left is the warhead in the form of an annular hollow charge; this too is adapted to the wing and the power plant, besides having considerably increased destructive power. Finally, the top right-hand corner shows the power plant, which has been adapted to the wing and warhead in particular through the choice of its maximum diameter. A special feature of this missile is that a single component simultaneously fulfils three functions. It serves as power plant, airframe of a flying wing aircraft and drag-reducing housing for the warhead.

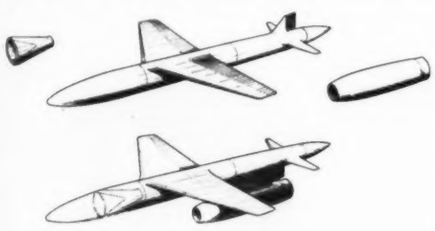
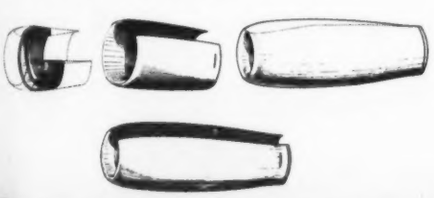


Fig. 6: Example of the "classic" combination of warhead, airframe and ramjet engine.

Fig. 7: Example of the optimum combination of warhead, annular wing and ramjet engine.



It is clear that the very design here leads to very much lower structural weights than those of any other category. In other words, the economy of a machine designed on these principles must be considerably greater than that of any other form designed for the same purpose.

Coleopters

Fig. 7 also clearly reveals two guiding principles:

— The advantage of using an annular wing provided it also forms part of the power plant.

— The advantage of using "self-lifting power plant," i. e., a power plant that provides the *whole* of the lift-producing surface.

As these design principles are new and there have been no previous examples of structures based on them, it has been possible for B.T.Z. to patent them.[1]

*

Though the machines based on the three basic laws described above represent the optimum technical solution at any given moment, it should be stressed that their *absolute* value (as in other solutions) will be improved as further progress is made either in power plant design or in materials research etc. The following examples demonstrate the application of these basic laws to aircraft production.

Optimum organization of air defence (Example 1)

If the task set is to find the most economical solution to the problem of defending a country's air space, the systematic application of the basic laws discussed in the previous section inevitably leads to the following results as regards the most suitable *procedure*.

[1] For example, French basic patents Nos. 1,033,590 and 1,051,259.

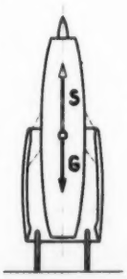


Fig. 8: Diagram of an unmanned missile for anti-aircraft defence: rotationally symmetrical central body with turbojet; annular wing.

— The device must be suitable for repeated use; hence it must be a weapons carrier, not itself a weapon;

— it should be unmanned, so that (in addition to other advantages) the efficiency of the defences is not affected by the always very limited number of operational fighter pilots;

— vertical take-off, to eliminate the need for prepared bases and the danger of surprise attacks on the defences;

— vertical landing at the centre of operations, to ensure uninterrupted employment without waste of time and thus reduce the number of devices required;

— maximum time of climb to 20,000 m: 3 minutes, and maximum speed in the range of Mach 2. This performance, together with efficient radar detection, would make it impossible for the enemy to swamp the defences, as even the latest bombers can be intercepted far ahead of the fighter bases.

The most suitable *power plant* is found to be:

— a combination of turbojet for take-off and return flight and a ramjet to provide the very high peak power required (though only for a few minutes; see *fig. 5*).

As regards the best possible *adaptation:*

— the ramjet, mounted coaxially with the turbojet must give the device the necessary lift; i. e., it must serve as wing (see *fig. 7*).

All these considerations lead to the device shown in diagram form in *fig. 8*. This diagram, which features aspects totally unfamiliar in aircraft and thus far removed from all natural forerunners, clearly reveals the basic characteristics of a new category of aircraft, known as COLEOPTERS. *The annular wing, whose axis of symmetry is coaxial with the thrust vector of the power plant, simultaneously forms part of the power plant, whose thrust exceeds take-off weight.*[2]

The diagram also shows a number of advantages typical of a coleopter:

— The annular wing permits of a much lower structural weight than is possible with any form of plane wing.

— The complete rotational symmetry of the annular wing is unsurpassable in simplicity and hence in cheapness of production.

— The absence of any tilting or folding mechanism avoids all the complications and sources of risk inherent in any convertible aircraft, along with the extra weight and costs these entail.

— A characteristic feature of the coleopter is that it can both take off and land vertically, and is thus completely independent of prepared bases.

— Coleopters are fully masters of the entire speed range from zero up to their design maximum speed, as the two flight ranges (vertical and horizontal) overlap sufficiently with large and small incidence.

[2] French patent No. 1.050,948.

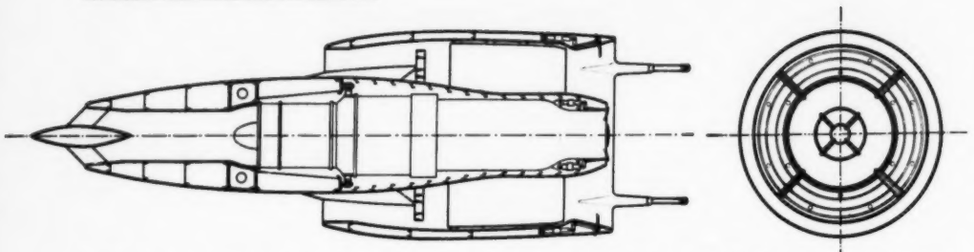


Fig. 9: Project drawing of the B.T.Z. *Charançon VI* pilotless interceptor, 17.5 ft. in length and 5.4 ft. in diameter.

— With its absolute aerodynamic rotational symmetry, the annular wing is ideal from the point of view of the complete equipment's manoeuvrability.

— Its ability to take off and land vertically, its aerodynamic rotational symmetry and its complete mastery of the whole speed range in both the horizontal and the vertical, make the coleopter independent of the weather for both take-off and landing.

— With the annular wing built as a ramjet, the top speeds already obtainable are in the region of Mach 2.

— The self-lifting ramjet is, by its very nature, always over-dimensioned and thus eminently suitable for the utilization of atomic energy. In particular, the working temperatures and heat transmissions required can be reduced to values that are within easy technical reach even today.

— The coleopter's rate of climb is necessarily very high, on the one hand because of the relatively high engine thrust (static thrust at least 1.25 times the take-off weight), on the other because of the very high additional power provided by the annular wing simultaneously serving as ramjet.

— The annular wing, which can be made very thin and on which practically no undesired aerodynamic forces arise, is the ideal wing for high speeds.

— If the whole of the annular wing is used to form a ramjet power plant, it represents the ideal wing design without dead weight and without parasite drag.

*

Fig. 9, which is based on this diagram, shows the project for an interceptor fighter, the *Charançon VI*.

Left to right are the central body forming the entrance to the power plant, containing for example the television eye and the firing radar, then an additional fuel tank fitted round the intake and finally the annular box structure which forms a single assembly unit with the annular wing. The central nacelle carries the 1,800 kg s. t. turbojet, and forms the cowling for this engine, which in turn is fitted with devices to control the jet (spoilers). Attached to the connecting arms are low-drag flame holders for the ramjet engine. Outside is the annular wing, which contains the main fuel tank and the remainder of the electronic equipment and has on its rear portion spoilers to direct its inner and outer flow. A cooling air conduit is fitted against the ramjet's combustion chamber, and finally the annular wing carries the four oleo-pneumatic legs for take-off and landing.

Experimental results show that the following values can be expected for this project:

Aircraft, fully equipped, without ammunition or fuel	850 kg
Ammunition	100 kg
Climb to 20,000 m	approx. 2 mins.
Service ceiling	20,000 m
Max. speed	2,100 km/h
Radius of action with rapid climb and supersonic flight, with reserves for return to take-off base in subsonic flight	125 km
Non-military range at 600 km/h	550 km

An interesting comparison can be made between the relative economy of the coleopter interceptor and of anti-aircraft guided missiles as regards structural weight, unit cost, consumption, range, probable effect per mission, and number of missions during the equipment's average life under wartime conditions. The result is a very high comparative factor in favour of the interceptor. This means, however, that the defence of a country by means of guided missiles would cost the nation many times as much as with coleopters of this type[3].

Optimum basic design for a civil aircraft (second example)

Using the same three basic laws again, the best procedure for the most economic civil aircraft to meet the given conditions would be:

— vertical take-off;

— vertical landing at the chosen spot on any type of ground, even with half the total engine power.

The most suitable *power plant* and best *adaptation* would be:

— ducted dual propeller turbine;

— propeller duct designed as wing unit.

The complete equipment would therefore be as indicated in *fig. 10*. Once again this diagram shows the coleopter's typical feature, the annular wing arranged coaxially with the direction of thrust and simultaneously forming part of the power plant.

Admittedly, this design may at first appear surprising, as the annular wing is in itself believed to be a typically bad wing because of its high drag coefficient. The present case is different from the above example of an interceptor, where it was easy to see that the annular wing—being fully justified by the other functions it performs—is the ideal form. In the present example there is almost a temptation to presume this procedure erroneous and, to get an even more economic solution, simply to substitute a plane wing for the annular wing. The interacting influences here are indeed somewhat more complex, so that I shall discuss them briefly before proceeding further.

Relative economy of coleopters and plane-wing aircraft, both with propeller turbines

To avoid misunderstandings it should be stressed that the following very brief remarks, based on rough approximations, are designed merely to fix the general magnitude of the parameters which affect economy. Exact values must be worked out separately in each clearly defined project.

The drag behaviour of an annular wing compared with a plane wing of the same lift capacity and the same aspect ratio is shown in *fig. 1* of the article by *Dr. Seibold* (elsewhere in this issue). If we compare two *flying wings* of the same weight and the same aspect ratio in economic flight, the ratio between the drags of annular-wing and plane-wing aircraft is found to be approx. 1.25.

However, flying wings cannot be built below a certain minimum size, since crew, passengers and payload must be housed inside the airfoil. Hence, small and medium-size annular-wing aircraft have fuselages in the form of central nacelles.

If we compare *fuselage aircraft* of the same weight and the same aspect ratio in economic flight, the ratio between the drags of annular-wing and plane-wing aircraft, with allowance for the influence of the fuselage, is found to be about 1.2. Here too, to be on the safe side, we shall take the figure of 1.25, i. e., against the annular-wing type.

If investigation stopped here, it might be assumed that fuel costs in small and medium size annular-wing aircraft would be at least

[3] It was inevitable that subsequent development work should produce further patentable discoveries. Examples are French patents Nos. 1,027,611 (fuel system), 1,033,692 (immobilization of television picture), 1,051,466 (fuel pump and fuel control), 1,063,247 (wing configuration), 1,087,825 (wing structure), and another eight patents applied for on wing structures, burner design, control and cooling of ramjets, spoiler control, landing gear struts and lightweight components.

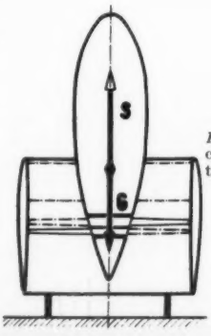


Fig. 10: Drawing of a civil coleopter with dual propeller turbines.

25% higher than fuel costs in plane-wing aircraft. However, the figure of 1.25 for the relationship between the L/D ratios—which is not a real criterion—is considerably more favourable to the annular-wing aircraft than the frequently encountered silhouette comparison and the comparison between wings of infinite aspect ratio. In the former case the value obtained is $\pi/2 = 1.57$ (to be found in *fig. 1* of Dr. Seibold's article above $\lambda = 0$), in the latter the value is 2. The figure of 2, however, is useless, since it is impossible to build either an annular wing of infinite diameter or a plane wing with infinite span.

The —unjustified—comparisons hitherto made, which have led to the condemnation of the annular wing as "unutilizable," have been based implicitly on *aircraft of equal weight*. But one of the main features of the new aircraft configuration is that it can be built more lightly, so that a coleopter can carry a considerably higher useful load for the same basic weight. It is therefore necessary, when comparing economy, to take the effects of weight into consideration.

As, basically speaking, an aircraft is merely a means of transport, I shall compare two aircraft of the *same transport capacity,* rather than of the same weight. Another condition is that both the plane-wing aircraft and the coleopter must be capable of taking off and landing vertically.

It must also be borne in mind that the static thrust of the ducted propeller in the annular-wing aircraft is at least 1.25 times the static thrust of the "free" propeller in the plane-wing aircraft (cf. also the above-mentioned article by Dr. Seibold), and that the weight of the annular wing of the same lift area is only about 40% of the weight of the plane wing (cf. the article by *Prof. Dr.-Ing. Hertel* elsewhere in this issue).

Finally, the assessment depends also on whether the whole useful load is divided in optimum fashion—i. e. in the ratio 1 : 1—between payload and fuel (to obtain the maximum possible transport capacity) or whether this distribution is limited by the safety provision that a normal landing can be made on half the engine power (in the event of 50% engine failure). We believe that this safety provision will always be required in civil aircraft.

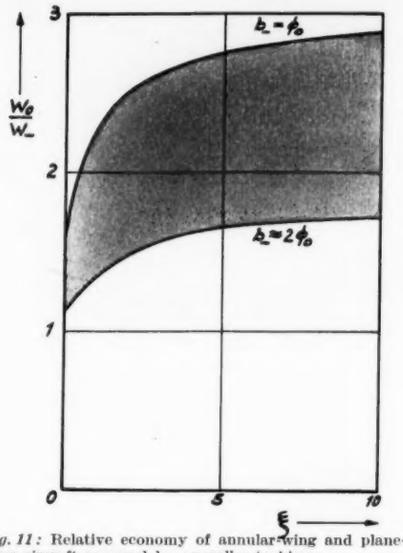


Fig. 11: Relative economy of annular-wing and plane-wing aircraft powered by propeller turbines.

Table 1 shows relative figures for payload (ratio of payload to gross weight), fuel and structural weight for annular-wing and plane-wing aircraft, in the form of statistical mean values obtained from a large number of projects. *Table 2* shows the mean values for the ratios of gross weight, drag, fuel consumption and structural weight for both fuselage aircraft and flying wings.

From *Table 2* it is clear that the less favourable L/D ratio in the annular-wing aircraft is more than compensated by weight advantages. *For the same transport capacity and the same aspect ratio, annular-wing aircraft require less than 50% as much structural weight as plane-wing aircraft and consume between 10 and 25% less fuel.* It should also be noted in passing that total drag in the annular-wing model is about 20% lower than in the equivalent plane-wing aircraft.

It may be objected that these comparative results do not allow for the fact that a plane-wing aircraft is easier than an annular-wing model to build with a more favourable aspect ratio. I shall therefore close with an *economy comparison* covering production and maintenance costs, as well as fuel costs, while at the same time allowing for the influence of *different aspect ratios* in the annular-wing and the plane-wing models.

So as to start with the simplest possible assumption, I shall introduce the parameter ζ, to indicate the relationship between the *procurement costs* (plus interest, repair and maintenance costs) during the life of the aircraft and the *fuel costs* arising during the same period.

The relative economy of an annular-wing compared with a plane-wing aircraft can be found, with the aid of this parameter, in *Table 3* for various ratios between the aspect ratio of

Table 1: Ratios of payload, fuel and structural weight proportions in annular-wing and plane-wing aircraft

	Proportional payload for an annular-wing compared with a plane-wing aircraft	Proportional fuel for an annular-wing compared with a plane-wing aircraft	Proportional structural weight of an annular-wing compared with a plane-wing aircraft
With optimum load distribution . .	1.35	1.35	0.70
With safety provision	1.63	1.15	0.70

Table 2: Mean values for a number of ratios, for aircraft with fuselage and without of the same transport capacity

	Gross weight of annular-wing to gross weight of plane-wing aircraft	Drag of annular-wing to drag of plane-wing aircraft	Fuel consumption of annular-wing to fuel consumption of plane-wing aircraft	Structural weight of annular-wing to structural weight of plane-wing aircraft
With optimum load distribution	0.63	0.78	0.89	0.46
With safety provision . . .	0.64	0.80	0.75	0.46

Fig. 12: Project drawing of the B.T.Z. *Ogre* economic guided missile, 6.6 ft. in length and 3.1 ft. in diameter. The missile would reach speeds of about 530 m.p.h. and have a tactical radius of action of 50 km.

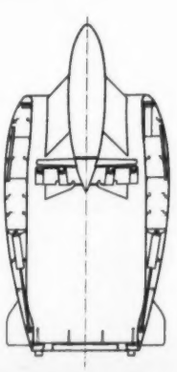
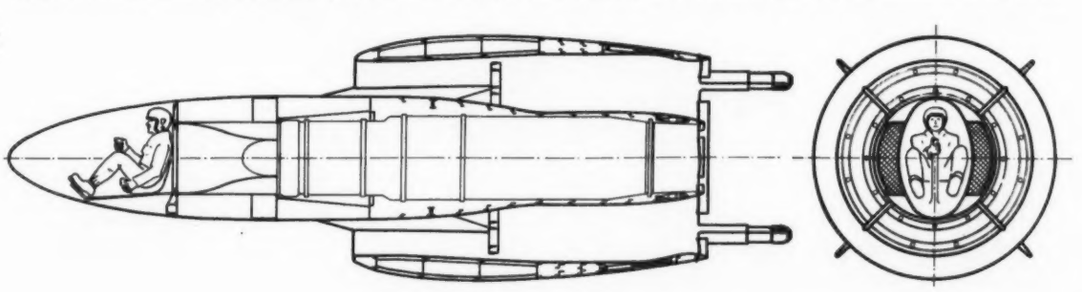


Fig. 13: Project drawing of the B.T.Z. *Bruche* light ground attack aircraft, 27.5 ft. long and 8.5 ft. in diameter. Power plant is an ATAR 101 turbojet of the latest version with afterburner, plus a ramjet engine formed by the annular wing and central body. Structural weight and equipment would amount to only around 3,970 lbs., while military payload is limited to 660 lbs. Max. speed has been calculated as 900 m.p.h.



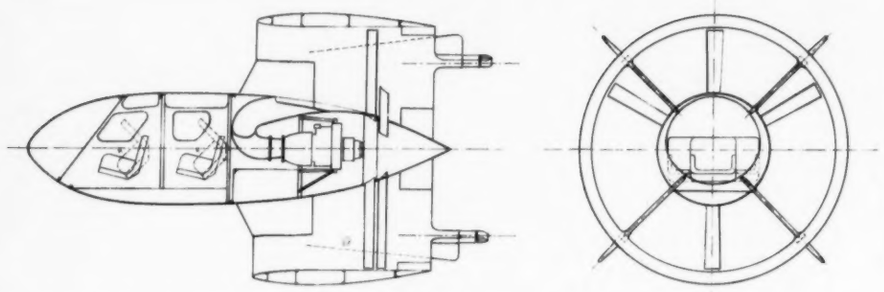


Fig. 14: B.T.Z. *Hanneton II* three-seat touring aircraft 18.7 ft. in length and 19.8 ft. in diameter. Power is provided by two 400 h. p. Turboméca *Marcadau* turboprops with two and three blade pusher propellers. The max. speed of this type should be approx. 280 m.p.h., and range 620 miles.

Table 3: Economy ratio W_o/W_{plan} for annular-wing and plane-wing aircraft of similar transport capacity

ζ	1				2				4				6				10			
λ_{plan}: λ_0	0.7	1	2	3	0.7	1	2	3	0.7	1	2	3	0.7	1	2	3	0.7	1	2	3
Fuselage aircraft . . .	2.30	1.94	1.36	1.11	2.52	2.11	1.49	1.22	2.70	2.27	1.61	1.31	7.80	2.35	1.66	1.38	2.88	2.42	1.71	1.40
Flying wing	1.96	1.65	1.17	0.95	2.14	1.80	1.27	1.04	2.30	1.93	1.37	1.11	2.37	2.00	1.42	1.15	2.44	2.06	1.46	1.10

the plane-wing (λ_{plan}) and that of the annular-wing aircraft (λ_0). Special attention should be given to the circumstance that the column for $\lambda_{plan}/\lambda_0 = 0.7$ gives the relative economy for *aircraft of equal bulk* (diameter of annular-wing aircraft equal to span of plane-wing aircraft). Maximum bulk will always have to be very restricted in aircraft for vertical take-off and landing. Secondary economic aspects also play some part, since both production and maintenance (housing) become more costly as dimensions increase.

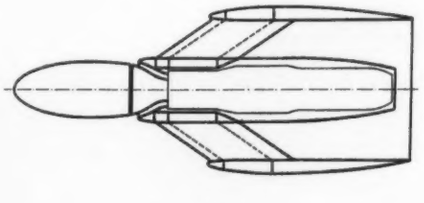
It is interesting to note at what relationship between aspect ratios the economy of the two concepts approach equality. For fuselage aircraft this is at $\lambda_{plan}/\lambda_0 = 5$, i. e., a plane-wing span 3.2 times the annular wing diameter. In flying wings the figure is 4, corresponding to roughly 2.8 times the span (referred to the diameter). It must be remembered, however, that the very simplified initial assumption on which Table 3 is based gives approximately correct values up to $\lambda_{plan}/\lambda_0 = 3$ at the utmost.

As the two limit values of 4 and 5 in the first approximation are well above this figure, the second step would have to be a new distribution of the weight proportions. This shows that, even for more than 3 times the breadth, the plane-wing aircraft is still markedly inferior to the annular-wing category as regards economy.

Fig. 11 gives as examples the relative economy of annular-wing and plane-wing aircraft of the same width and for a plane-wing model of twice the span of the annular-wing type of the same transport performance. Despite the fact that the method of evaluating is unfavourable to the annular-wing aircraft, the *comparative value for economy*, within the range of probable ζ values (for identical main dimensions) *is in the neighbourhood of 2.5* in favour of the small and medium annular-wing types. For the plane-wing aircraft of double the span there is still an advantage of the order of 1.5 in favour of the annular-wing model. Similar values—of over 2 and 1.5—are found for the flying wing.

Another point: to match an annular flying wing less than 10 m. in diameter, with a take-off weight of about 35 tonnes, an otherwise equivalent plane-wing model would have to have a span of more than 30 m. of *extremely* light construction. Even leaving aside the possibility that structural difficulties might be insuperable, these dimensions seem to me to be out of the question for vertical take-off and landing aircraft. Even a coleopter 8 to 10 m. in diameter could therefore be compared only with classic aircraft for use with runways, so that not only the cost of installing and maintaining air bases but also—at any rate in Europe—the annual loss in agricultural crops must be added to the calculation.

Fig. 15: Mail aircraft with S.N.E.C.M.A. R 105 turbojet and reheat: length 18 ft., diameter 6.6 ft., speed 530 m.p.h. (at 36,000 ft.), range (with 550 lbs. payload) 1,240 miles.



To sum up, the turboprop coleopter concept shown in the diagram has at least double the economic efficiency of the equivalent plane-wing model. Another aspect of the absolute quality of the coleopter is the fact that, with its very high load capacity—more than 50% in relation to take-off weight, more than 100% in relation to structural weight—it has remarkably high values compared with the plane-wing aircraft requiring runways. As soon as more advanced power plant with improved consumption and performance weight are available, these advantages will be even more marked.

Field of application of the coleopter

In view of their considerable economic superiority, coleopters are particularly suited to those fields of aviation in which a few minutes of very high peak performance are required. In the more distant future the whole range of supersonic interceptors, carrier-based supersonic fighters, certain missiles (*fig. 12*) and fast tactical ground support aircraft (*fig. 13*) will be their main field of application.

They will also be useful where speeds of 400 to 800 km/h and ranges of up to 2,000 km are required, i. e., high-speed private aircraft, communications aircraft, 12-seat medium-stage aircraft, mail aircraft, medium transports and cargo aircraft (*figs. 14 and 15*). Operations requiring a cruising Mach number of the order of 2 and an unlimited range will also fall to special coleopter versions[4].

Finally, missions where near-sonic speeds suffice but where smallest possible dimensions are demanded—e. g., carrier-based fighters, tactical ground support aircraft, mail aircraft, also come into consideration.

Expendable ground-to-ground and air-to-ground missiles can also be built economically as variants of the coleopter.

On the other hand, coleopter versions of ground-to-air guided missiles, while more economical than other categories, are less economical by at least one order of magnitude than a good intercepter fighter of similar configuration.

Present and future in coleopter development

The past four years have been fully occupied with developing the basic principles; assessing value compared with optimum solutions along classical lines; measurements in subsonic, sonic and supersonic wind tunnels; their evaluation and incorporation in projects; aerodynamic, thermodynamic and static stress investigations;

[4] According to French patent No. 1,078,563 they can meet these requirements with the lowest structural cost and smallest dimensions, using nuclear energy.

preparation of detailed projects for a number of coleopter variants; and detailed design studies. The result is sufficient documentation, backed by measurement data, to enable the development of suitable coleopter variants to be undertaken without technical hazard.

A beginning has therefore been made on the development of certain variants. Rate of progress on this work is determined by the limited funds available, hitherto provided solely by S.N.E.C.M.A.

Conclusion

Starting from the premise that *economy* is the only true criterion in engineering, the road leading to optimum technical solutions has been indicated. Coleopters have been found to be the logical final outcome of present trends towards more economical concepts, via "derefinement," lightweight construction, better power plant equipment or "independence of airfields."

The great economic superiority of coleopters compared with aircraft configurations hitherto used was then demonstrated. Then the branches of aviation most suited to the various forms of coleopters because of their outstanding economy were indicated.

This gives, in very rough outline, the following picture of civil aviation in the future:

Long-range equipment will differ little in external aspects from today's equipment. Cargo, passenger and luxury aircraft will continue to be powered by propeller engines or turbojets. The drive towards increased economy will here be met by fitting power plant with improved consumption and by standardized use of rocket engines for assisted take-off. There will be keen competition for technical superiority between new lightweight high-performance diesel engines and liquid-cooled gas turbines of improved structural materials.

Short and medium-stage aircraft for passengers or freight, however, will be replaced by the more economic coleopters with propeller turbines.

Helicopters, small and large, will win and hold a—very limited—place for the lowest ranges, above all as air taxis and air buses.

The most striking structural innovation in aviation, however, will be provided by the small 3-to-4-seat coleopter. This equipment will give the private individual a very fast and economical means of transport, leaving him full freedom of travel time and destination.

S.N.E.C.M.A. and the Coleopter

BY DR. ING. HERMANN OESTRICH

DIRECTOR OF ENGINEERING, SOCIÉTÉ NATIONALE D'ÉTUDE ET DE CONSTRUCTION DE MOTEURS D'AVIATION (S.N.E.C.M.A.), PARIS

Born at Duisburg on December 30th, 1903, the author of this article graduated from the Berlin Institute of Technology and later joined its teaching staff. From 1928 to 1935 he worked at the German Aeronautical Research Institute (DVL) at Berlin-Adlershof, which he left to become Director of Turbine Engine Engineering of B.M.W. in Munich. This position he held until 1945. In 1950 he was appointed Director of Engineering of S.N.E.C.M.A., the French aero-engine concern, an appointment he still holds today.

While it can now be confirmed that for the last two years the S.N.E.C.M.A. aircraft engine concern has been engaged in the development of vertical take-off aircraft, it is also permissible to ask why an engine company has branched out into the field of aircraft design. The fact simply is that the evolution of aeronautical engineering has brought airframe and power plant into closer and closer interdependence, leading finally to an amalgamation of the two into a "flying power plant".

Within the scope of this development, S.N.E.C.M.A. has concentrated on the fast-flying, short-range turbojet-powered V.T.O. aircraft, because in this field interesting solutions are feasible, particularly in conjunction with the use of an annular wing for the simultaneous generation of lift and thrust. In the design of such aircraft the patents taken out by Dipl. Ing. H. von Zborowski are being exploited.

Brief description

This new species of aircraft, christened "*Coleopter*" by its creator, is characterized by an annular wing which serves simultaneously as lifting surface and power plant housing *(fig. 1)*. The central body of the aircraft contains the control compartment in its forward portion, and the turbojet, suitably cowled, in the rear; the annular wing serves as the shell of a ramjet engine. Fuel tanks and various items of equipment are housed in the wing. The latter has a low structural weight and is easily produced. The light weight, combined with suitable light engines, makes possible vertical take-off and vertical landing. In addition, flying performance is attainable which is limited only by the strength of the structure and the resistance of the human body. No special mechanism is required to effect the transition from vertical flight to horizontal high speed flight. With the help of a swivelling seat the pilot can adapt himself to changes in the flying attitude.

*

Problems to be Solved

Before starting construction of an aircraft of this type, several problems must be investigated:

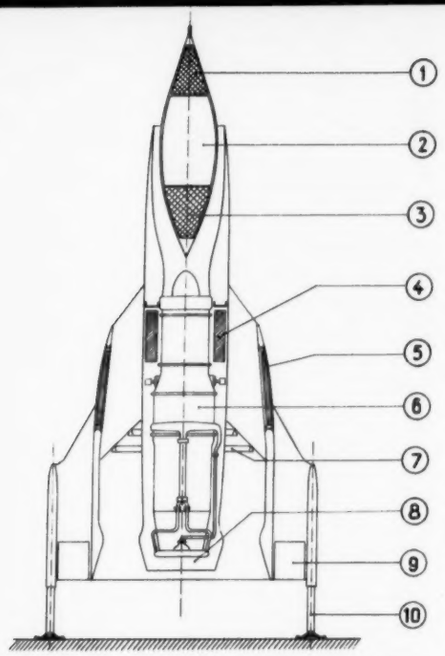


Fig. 1: General structure of a coleopter: 1 – airborne radar; 2 – pilot cabin; 3 – equipment compartment; 4 – fuel tank; 5 – fuel tank; 6 – turbojet with reheat; 7 – flame holder for ramjet engine; 8 – gas jet control; 9 – aerodynamic control surfaces; 10 – shock-absorber legs.

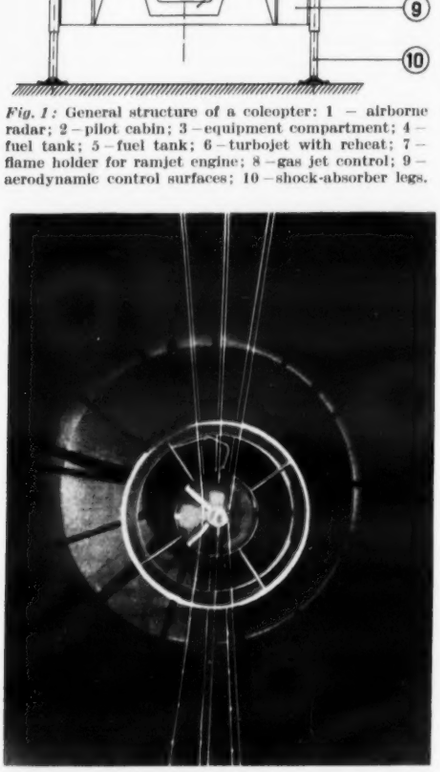


Fig. 2: Coleopter model (central nacelle and annular wing) in the subsonic wind tunnel.

— aerodynamics of the annular wing
— stability at take-off and landing
— limitation of structural weight
— ramjet power plant.

Initially, detailed studies had to be made in the wind tunnel of the properties of the annular wing in general and the coleopter configuration in particular. Test data are available for speeds up to Mach 1.4 and the studies are now being extended to higher speeds *(fig. 2 to 5)*. Particular attention is being paid to the inter-action of annular wing and ramjet.

The problem of vertical take-off was solved in the development of the V.2 rocket, and much knowledge gained at that time can be applied to the coleopter. However, owing to the rotating components of the engine, the problem became more complicated in the coleopter.

During take-off the coleopter is borne by the engine jet. If the line of jet thrust passes through the centre of gravity of the aircraft, the latter shows a tendency to move in a straight line. On the other hand, inadvertent or intentional deviations of the jet axis from the centre of gravity create a turning movement. Since no aerodynamic forces act on the aircraft at take-off, the aircraft's motion is determined solely by the force and direction of the jet.

Two different jet-pipe systems were tested to obtain control of the direction of thrust.

In the first system modifications in the jet efflux area and deflection of the jet direction for control of the aircraft (in altitude and laterally) are achieved *purely aerodynamically* by the injection of air into the gas jet.

A second, mechanical system features spoilers for the control of the jet direction and modification in the efflux area *(fig. 6)*.

In both cases control of roll is effected through deviation of the jet by means of guide surfaces or air injection at right angles to the jet.—Detailed experiments with methods of stabilizing at take-off and landing as well as in normal flight were carried out in the laboratory and the wind tunnel with several different models. The rotor of the turbojet was simulated by electrically driven inertia masses.

Here is was found necessary to relieve the pilot to a large extent during take-off and landing with the help of automatic gyro controls. The principle of this gyro control system, too, was tested, and free vertical flights were carried out by a flying model in a disused test hall *(fig. 7)*[1]. The power plant was a S.N.E.C.M.A. *Ecrevisse* pulse-jet of 100 lbt. The jet control nozzle consisted of four spoilers actuated by electromagnets. This control system operated with damping gyros to measure the model's

[1] The model made its first flight on March 31st, 1954.

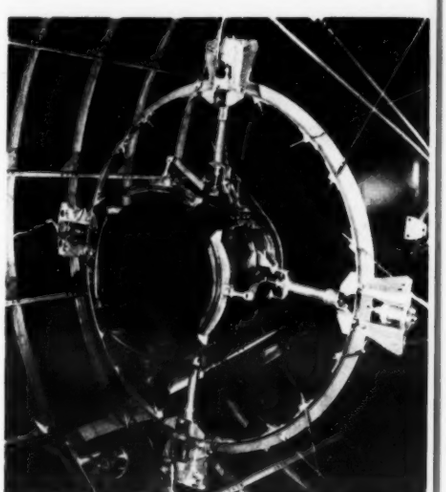


Fig. 6: Spoilers, operated by electro-magnets, to control the gas jet (in altitude and laterally) in the rear of the S.N.E.C.M.A. *Ecrevisse* pulse-jet engine.

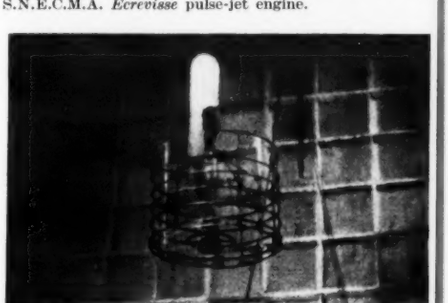
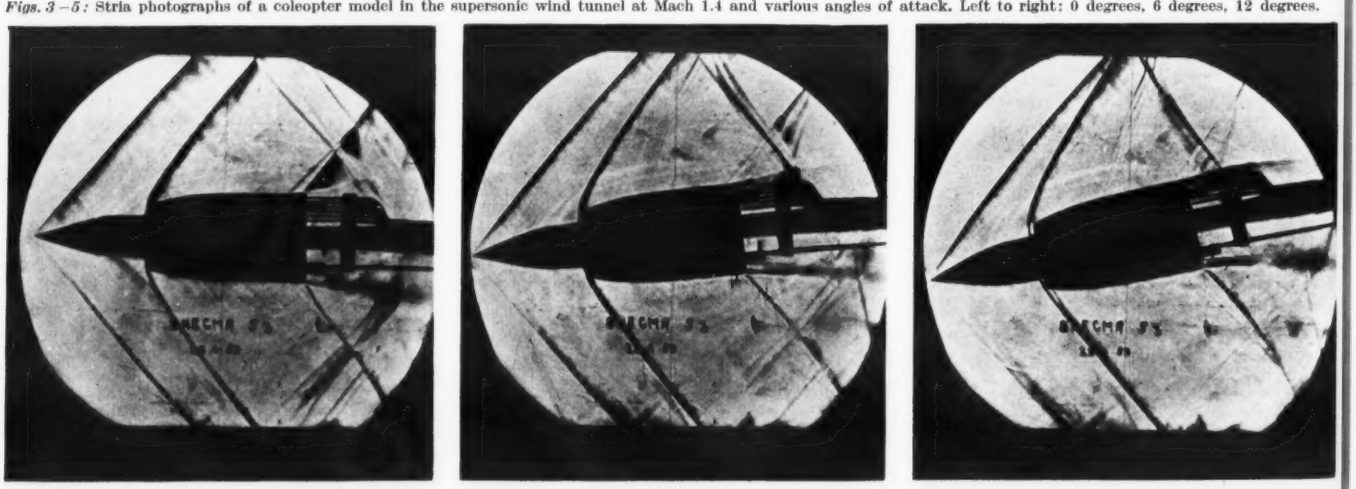


Fig. 7: Free-flying S.N.E.C.M.A. *Ecrevisse* engine (first flight on March 31st, 1954).

Figs. 3–5: Stria photographs of a coleopter model in the supersonic wind tunnel at Mach 1.4 and various angles of attack. Left to right: 0 degrees, 6 degrees, 12 degrees.



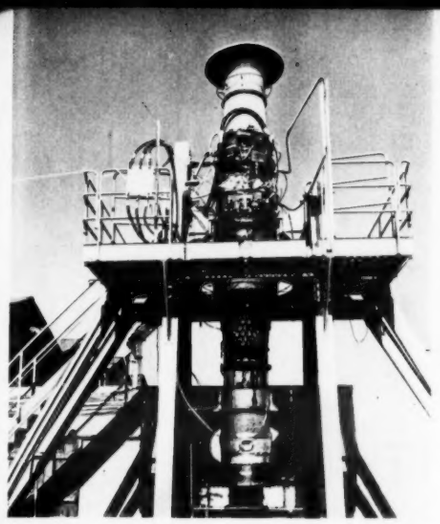


Fig. 8: S.N.E.C.M.A. test rig, to test vertical take-off versions of the ATAR 101 turbojet.

angular velocities about the axes involved. The non-existing aerodynamic damping was replaced by artifical damping.

Applied to a full-scale aircraft, the pilot using this control system would have to shift, with his control column, the moving coil of a potentiometer connected with the appropriate gyro instrument via a bridge circuit. Relays would then actuate the magnets of the spoilers. For stabilizing the aircraft one would thus use the so-called "yes-no" principle (also known as "black-white" steering), though control impulses can be applied continuously.

Since for its vertical flights the model was initially fitted merely with a make-shift wing, the next step was the addition of a light annular wing. Here, experience was gathered in several respects. For example the revolving masses of the gas turbine produced rotating and gyroscopic movements at low flying speeds, i.e., so long as no stabilizing aerodynamic forces were available. Roll stabilization was thus found also to be necessary to compensate for rolling moments occurring as a result of sudden changes in the rotational speed of the turbine. By this means the pilot can be relieved of the necessity to control roll in vertical flight. In horizontal flight it is possible to compensate for gyroscopic effects by actuating rudder and elevator surfaces.

The basic system of this control method works with artificial damping through gimbal-

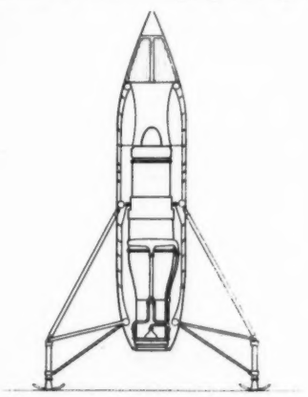


Fig. 9: ATAR "flying power plant," with fuel tanks, remote control equipment and oleo legs.

mounted gyros for all three axes. By the use of directional gyros the pilot is given control "feel" as in conventional aircraft. A slight inclination from the vertical initiates a lateral movement which enables the pilot to select his landing spot. This lateral inclination is also useful in the elimination of cross-wind effects.

In a normal fighter the turbojet always works in practically horizontal position except for very short periods, e.g., during aerobatic manoeuvres, and the requirement of starting and continuous operation in the vertical position necessitates certain modifications. To enable all necessary tests to be carried out, a special vertical test bench was built for the ATAR 101 jet engine *(fig. 8)*.

For the testing of gas jet steering, compensation of gyroscopic effects, as well as for vertical take-off and landing tests a "flying ATAR" *(fig. 9)* was used. This was a *free-flying engine* which carried fuel tanks and remote-control instruments within its cowling.

In V.T.O. aircraft structural weight is of considerably greater importance than in conventional designs. Regarding the airframe the annular wing offers special advantages since its basic shape is a pipe which behaves unusually favourably under static and dynamic loads. The result is that the airframe weight of a coleopter amounts to only about half the weight of a comparable conventional aircraft.

Needless to say, similar attention must be paid to engine weight. Investigations have shown that V.T.O. aircraft can be built even with engines having a specific weight of 0.25 lb./lbt. (take-off). However, engine weights of 0.20 lb./lbt. and less should be aimed at. In the latest version of the ATAR 101 E of 7,700 lbs. (3,500 kg) static thrust S.N.E.C.M.A. has attained a specific weight of 0.235 lb./lbt.

The last problem concerns the ramjet engine, development of which is proceeding today all over the world. In the coleopter it shows an unusual feature inasmuch as it operates with relatively small temperature increases.

The dimensions of the annular wing, which simultaneously acts as the jacket of the ramjet engine, are determined by lift requirements. The diameter of the annular wing in turn determines the rate of air flow through the ramjet engine—this rate being considerably greater than is required for thrust generation. The result is, on the one hand, a low heat increase in the ramjet engine and, on the other, a great power reserve for the coleopter. These low temperatures facilitate the construction of the annular wing and the engine cowling. However, the lean mixture ratio requires special measures for ignition and to maintain combustion.

*

Performance

Coleopters can be built for a variety of uses, single or multi-engined, driven by jets or propeller engines.

At the outset S.N.E.C.M.A. concentrated on the single-jet coleopter, in the belief that with this configuration it would achieve success in a minimum of time. Detailed studies of several projects disclosed that with the turbojets available today, combined with the use of reheat, extraordinary flying performances can be obtained. However, the ultimate solution aimed at is a coleopter powered by a turbojet, afterburner and ramjet, as with this combination performance can be obtained such as would never be reached by conventional aircraft. For example, a military coleopter powered with the ATAR 101 E would, according to the studies carried out, climb to a height of 49,200 ft. (15,000 m) in about two minutes and exceed maximum speeds of Mach 2.0. Performance would no longer be limited by the aerodynamics of the aircraft or the amount of thrust available, but by the human body, as well as certain items of equipment and finally the structural materials, which must withstand the high temperatures generated in supersonic flight. In the absence of such heat problems even higher speeds could be reached, since the reserve power of a ramjet increases with flying speed.

A secondary consideration is that the coleopter configuration offers vast possibilities also in the development of pilotless missile-like aircraft.

Take-off, Flight, Landing

Let us now consider the individual phases of flight characteristic of the coleopter.

During vertical take-off *(fig. 10)* the aircraft is lifted by the engine jet and within a few seconds reaches a height of about 650 ft.

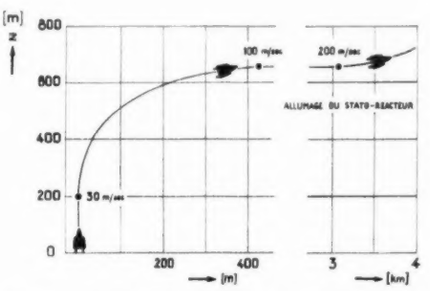


Fig. 10: Trajectory of a coleopter after take-off (Allumage du stato-réacteur = ignition of ramjet).

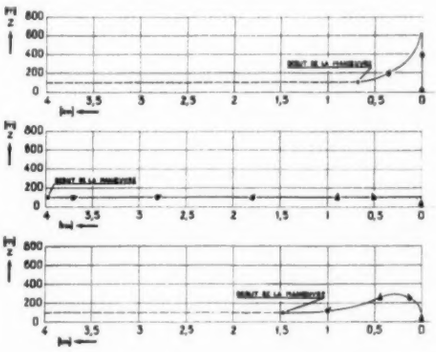
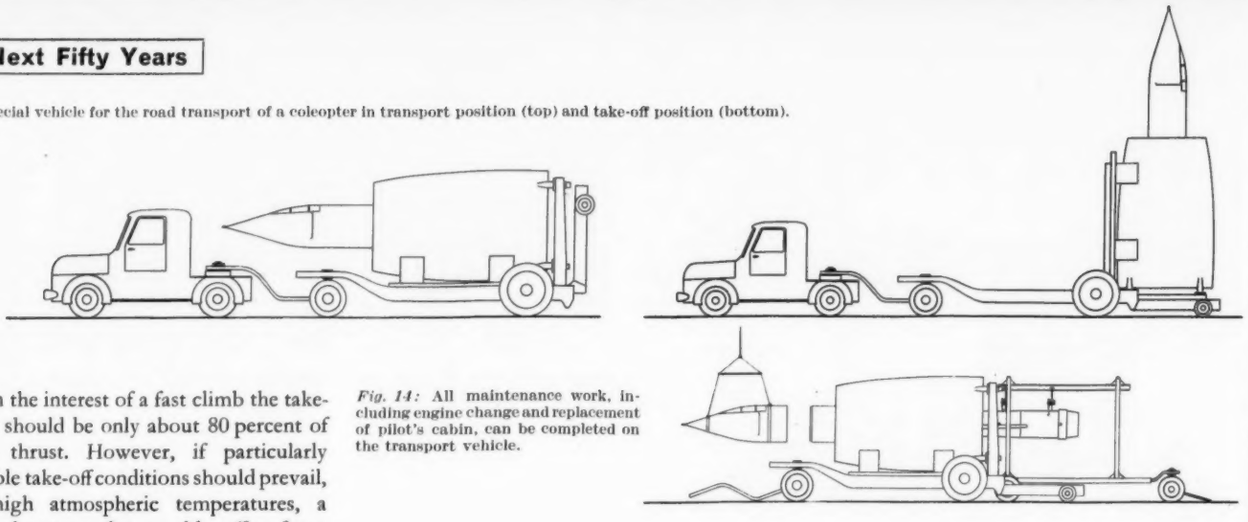


Fig. 11: Three methods of landing a coleopter: "landing chandelle" (top); braking at constant altitude (centre); combination of "landing chandelle" with gradual braking (bottom). The beginning of the landing manoeuvre is marked "Début de la manœuvre" in each case.

Fig. 13: Special vehicle for the road transport of a coleopter in transport position (top) and take-off position (bottom).



(200 m). In the interest of a fast climb the take-off weight should be only about 80 percent of the static thrust. However, if particularly unfavourable take-off conditions should prevail, such as high atmospheric temperatures, a 10-percent thrust surplus would suffice for a safe take-off.

Upon reaching a rate of climb of about 5,900 ft./min. (30 m/sec.), the coleopter begins a gradual transition to horizontal flight, for which purpose it is given a slight forward inclination by means of its jet control vanes. During this transition the flying speed increases constantly, so that the aerodynamic controls begin to be fully effective. If another climb follows immediately, the coleopter—using its ramjet—can reach a height of 49,200 ft. (15,000 m) within two minutes of take-off, and even the climb can be effected at supersonic speed.

For landing, the coleopter approaches its landing site with the engine throttled and at reduced speed, at a safety height of about 325 to 650 ft. (100 to 200 m). The transition to vertical descent can take place in several ways *(fig. 11)*.

The first is a "landing chandelle" for the purpose of braking speed and changing over into vertical descent. By pulling up the aircraft steeply, forward speed is reduced to zero, and the machine then initiates its jet-borne descent.

A second landing method provides for braking the coleopter at constant height: slow pull-up until the aircraft is stationary in the air, followed by the vertical descent.

In the first case the aircraft has to climb from the safety height to between 1,970 and 2,300 ft. (600 to 700 m) again and therefore has a longer descent, while the second method has the disadvantage of a longer approach distance. A combination of both methods therefore seems to offer the most promising solution.

In the final phase of the landing the rate of descent is gradually reduced until the aircraft touches down at nearly zero speed. In this phase an automatic landing system, working on the basis of altimeter and airspeed indicator readings and directly taking over the throttle control, could do much to relieve the pilot. To compensate for the effects of a crosswind of 80 ft./sec. (25 m/sec.) an incidence as low as 2 deg. is sufficient.

Fig. 14: All maintenance work, including engine change and replacement of pilot's cabin, can be completed on the transport vehicle.

*

Safety

In cases of ground mist, night flying, destruction of ground facilities, airframe damage or engine failure the coleopter is superior to conventional aircraft.

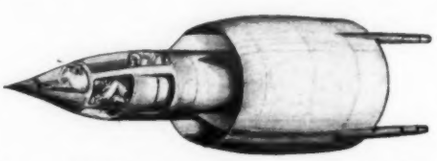


Fig. 15: Conception of a military supersonic coleopter with turbojet, afterburner and ramjet.

For landing under no-visibility conditions it can descend along a radio guide beam and touch down at zero speed; at night airfield lighting is not necessary. If its home base is destroyed, the coleopter can land and take off again at any other point.

In case of airframe damage, say, through enemy action, the aircraft would remain manoeuvrable thanks to its jet control and could land anywhere as long as the power plant remains operative.

Should the power plant fail the aircraft would be abandoned and the crew would bail out by parachute. Leaving the coleopter is relatively hazard-free, since one of its normal flying manoeuvres consists of reducing speed practically to zero. Admittedly bailing out during take-off and landing procedures would be useless, but the time required for these procedures is considerably shorter in the coleopter than in conventional aircraft.

*

Operation

For a *short-range interceptor* (target protection or normal air defence) the time required to reach operational height and the enemy is the decisive factor *(fig. 12)*. In view of the high speeds of modern bombers and the brief warning periods available in Europe it is easy to calculate that a fighter of conventional conception is virtually incapable of intercepting the enemy before he reaches the target and of preventing him from dropping his bomb load.

On the other hand, the coleopter seems to be "tailored" exactly to these requirements—it has a very high rate of climb, it requires no elaborate ground facilities, its operational bases are practically indestructible and easily camouflaged.

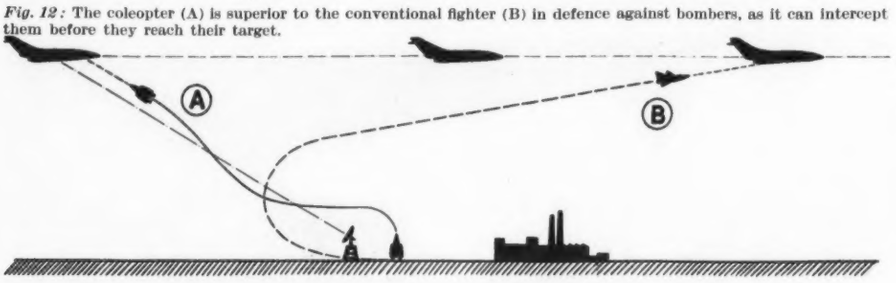
Movement on the ground is accomplished by a special vehicle *(fig. 13)*. The coleopter is transportable without dismantling of any kind. Furthermore, all maintenance work, including engine change and replacement of the pilot's compartment, can be performed on the transport vehicle.

In view of this large degree of autonomy the coleopter is especially suitable for ship-borne operation. As soon as aircraft can take off even from small areas aboard ship, gigantic expenditures on modern aircraft carriers will become redundant.

*

As has often been the case in the field of engineering, military equipment will also no doubt act as the pacemaker for civilian developments in the case of the coleopter. Again and again it has become clear that only a certain lack of regard for conventional development has made it possible to achieve decisive progress and pioneering performances. These are then followed by years of refinement and improvement. The development of the coleopter will probably run along similar lines.

Fig. 12: The coleopter (A) is superior to the conventional fighter (B) in defence against bombers, as it can intercept them before they reach their target.



The Air Arm of the Future

BY * * *

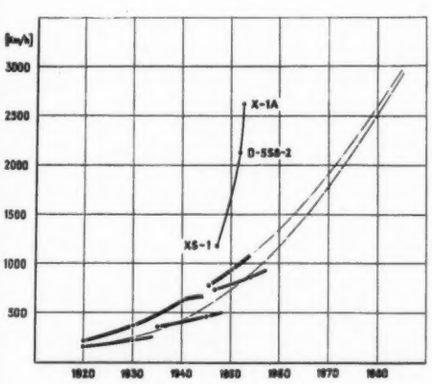
The ever-increasing power of destruction created by human ingenuity has never yet discouraged man from seeking even greater destructive power. Today, alarmed by its own discoveries, the world begins to question the future. For the first time since history and geology began to delve into the ages, the new means of destruction now in the hands of man approach those primitive powers which modified the structure of the globe, creating and annihilating continents, wiping out life and causing mutations of matter. Yesterday already the nuclear fission bomb flattened the heart of cities. Tomorrow a single thermo-nuclear projectile could overwhelm and erase the vastest of man-made agglomerations.

The years to come will be marked by the threat of a general cataclysm, set off this time by man against himself. But it will be a very long time before man will begin to seek common salvation by agreeing to renounce the use of mass destruction weapons. He will regard reciprocal intimidation as a surer means to his end. Man welcomes the present given him by science, the Pandora of modern times, but being better informed than Epimetheus, it is doubtful whether he will open the famous box from which would escape evils of an entirely different calibre from those which have flooded the universe since the fable was told.

This intimidation, this reciprocal discouragement from engaging in a trial of strength, will thus be founded on a scientific and engineering effort made simultaneously by all potential adversaries. Once the outbreak of a general conflagration has been postponed by the certainty of retaliations which would be equally unbearable for both sides, the enmity between the two camps will—if it persists—assume a thousand different forms ranging from the Cold War of the type which has marked the past few years in Europe, to local armed conflicts fought with conventional weapons of the kind which recently caused much bloodshed in the Far East. This formula of political coexistence will be the determining factor in the coexistence of two efforts—one scientific and technical to enlarge the nuclear arsenal of intimidation, the other aiming at ensuring an adequate supply of conventional weapons necessary for combat in "minor" theatres of war.

The McDonnell F-101A 'Voodoo' the U.S.A.F.'s newest escort and long-range fighter, is capable of carrying an atom bomb. Gross weight is about 20 tons.

Speed advance of combat aircraft, in three phases: piston engines from 1920 to 1945; jets from 1940 onwards; rocket engines from . . . ? ▬ bombers, ═ fighters, — experimental rocket aircraft.

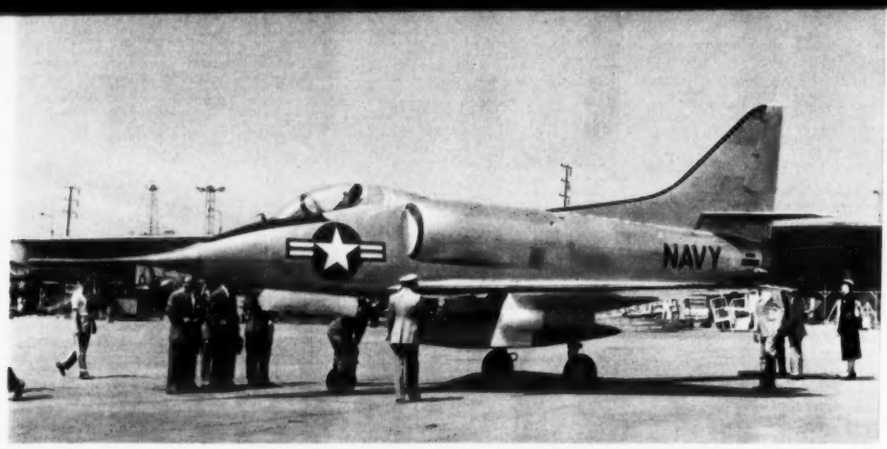


So far as the air arm is concerned, it is obviously the first of these two efforts which interests us here. From what basis will this effort start? To simplify the problem presented by the evolution of the air arm, we shall have to consider three elements: the explosive, the vehicle and the guidance of the vehicle-explosive combination.

Today the explosive already has assumed two entirely new characteristics which have completely upset the strategic concepts evolved barely ten years ago: its power and its weight. The fact is that within ten years we have advanced from a small fraction of a square kilometre—the area of total destruction of a V2 with a warhead of 1,750 lbs.—to the 500 square kilometres of destruction by a fully tested "model" of a thermo-nuclear projectile. As regards size and weight of the bomb, these have greatly been reduced since the "Enola Gay" dropped the bombs which provoked the surrender of Japan in World War II. A few months ago "Air Force," the monthly published in Washington, predicted that aircraft rockets fitted with atomic warheads would be introduced in due course. And it is already several years since the Republic F-84 *Thunderjet* "conventional" fighter-bomber became an A-bomber. With an all-up weight of eight tons it represents a potential of destruction superior to a formation of several hundred of the old four-engined heavy bombers attacking with TNT bombs.

The aerial vehicle, still flown by a human pilot, reaches transonic speeds today. Thanks to the increase in propulsive power and the improvement in engine efficiency, the compromise between speed and range no longer imposes severe limitations on the operating speed, one of the prime advantages of the air arm. With the advent of vertical take-off methods, as yet in the experimental stage, new concepts are beginning to appear which will gradually free the air arm of the heavy burden imposed by horizontal take-off and landing. Converted into firing ranges, the earth's vast desert regions today serve for guided missile tests and experiments. Man is beginning to control his missiles' trajectory from the ground. Still in their infancy yesterday, missile guidance systems are making gradual progress. While the human pilot will long continue to be essential for seeking out and attacking mobile targets on the surface of the earth, automatic devices are beginning to replace him in the attack of aircraft in flight and in the bombardment of major stationary targets on the ground.

Such is, *grosso modo*, the situation today. How will it evolve? To try to forecast its successive changes over a long period, to predict what the "air arm" will look like in A. D. 2000, would need the skill of an oracle. The air arm depends so much on a branch of engineering continuously in headlong evolution that a long-term prophecy is difficult. Let us take, as an example, the growth in the speed of combat aircraft (see graph). From 1920 to 1940 the increase was gradual: about 12 m.p.h. a year for fighters, about 8 m.p.h. a year for bombers. The adoption of jet propulsion produced a first break in this continuity. Benefiting by an abrupt speed increase of nearly 200 m.p.h., the bomber drew the most significant advantage from this engineering advance. Since that time the two curves have resumed their relative positions, although both have become steeper. For the fighter the speed



"Flyweight" among heavy bombers – carrying A-weapons – could be the Douglas A4D *Skyhawk*.

increase now is in the order of 20 m.p.h. per annum and for the bomber about 15 m.p.h. on an average.

Now let us project these curves into the future. They would show speeds of about 1,250 m.p.h. for operational matériel of the year 1970 and about 1,850 m.p.h. in 1990. It is clear that by that time the very definition of the carrying vehicle will have changed so radically that there would be no sense in projecting the results achieved since 1920 over several decades. The curve of typical speeds obtained with experimental rocket-propelled aircraft proves this conclusively. Here the annual speed advance amounts to more than 130 m.p.h. and the corresponding curve looks like one branch of a hyperbola.

If we examine not only speed but also operational endurance, equipment and armament requirements, the curves obtained are likely to follow an entirely different course.

While it is not possible to stay very long within the bounds of plausibility when sounding the remote future, the present does supply us with plenty of useful pointers to the immediate future and even some distance beyond. Thus we can envisage three phases: the first covers the period of operational use of equipment now in the early testing stage or scheduled to enter this stage very shortly. In view of the longer and longer development times required, let us assume that this period will take us through 1965, the year in which a new "generation" of techniques—albeit with a wide margin of overlap—will replace the former one. This new generation will certainly last five or six years and will be characterised by the operational introduction of equipment still in the preliminary project stage today. It would be futile to try to stake out the course of technical evolution more than twelve or fifteen years hence. All we can do is to record the broad trends of the future.

*

From 1955 to 1965

The awesome increase in the power of destruction of a single projectile, accompanied by a substantial reduction in its weight and bulk, should affect the concepts of our strategists and, on the rebound, those of our technicians. The "fly-weight heavy bomber" has come into existence. Single-handed it carries more power of devastation than thousands of B-29 *Superfortresses* or even B-36's—had the latter been in existence—each carrying ten to twenty tons of TNT in their vast bomb bays. The Douglas A4D *Skyhawk,* perhaps also a special version of the Lockheed XF-104, may become this tremendously powerful "fly-weight" bomber. This will spell the end of the classical fighter-versus-bomber ballet. What fighter cannot carry a warload much heavier than the weight of an atomic projectile? Where is the fighter-bomber, whose external fuel tanks or napalm containers or rocket batteries do not present a much greater frontal area than an A-weapon? Guiding systems, navigation instruments, target identification devices and radar fire-control systems are much more complicated, require more equipment, take up more space and weigh more than the all-powerful atomic weapon. The only vehicle which will continue to employ to some extent the techniques of the bomber of today will be the machine carrying the atomic bomb over very long distances and forced to drop it on its target under any weather conditions.

Creation of *experimental rocket aircraft* caused speed curve to leap upward steeply. Among most recent rocket-powered aircraft are the Bell X-1A and X-1B. The X-1A has reached a speed of 1,650 m.p.h. and an altitude of 90,000 ft.

As regards short-range and medium-range bombing—over distances less than 400 to 500 miles—any relatively light and sufficiently fast aircraft can perform this mission. And tomorrow any guided missile—all the more easily developed since it already exists today, though not yet fully developed—will take the place of the piloted aircraft in the attack of stationary targets. The air arm will no longer be defined by the conventional classification of today, based on a given number of "fighter aircraft" and a list of "bomber" squadrons, but purely by its atomic potential. Without atomic weapons, this air arm would be a purely defensive force. With the A-bomb it becomes a weapon of offense, though it may not possess a single "bomber". What counts is the distance that must be covered to reach the targets whose destruction will have a decisive effect on the enemy's conduct. The nature and the number of the "aerial vehicles" have become of secondary importance. The new explosive has become the sole yardstick, the all-powerful master.

Are there any other criteria for the determination of the equipment which will become operational in the period ending, according to our admittedly arbitrary estimate, in 1965? The distance to be covered is the first, all-weather capability is the second. The third is, perhaps, the "habitat" of the aircraft, i. e., the atmosphere, whose features vary greatly according to altitude. Structures, aircraft skin, cooling at high speeds may have to be adapted specifically to the operational altitude for which each aircraft is designed. High-flying machines and low-level aircraft may have to be designed, built and equipped along vastly different lines.

The omnipotence of the "air-vehicle-nuclear explosive" combination gives unique advantages to the offensive. The B-17 *Flying Fortress* squadrons in Europe and the B-29 *Superfortress* formations in the Far East were easily spotted on the radar screens long before they reached their targets. The least one can say is that they used to arouse the watchman's attention. In spite of the rude lesson of Hiroshima, the single "vehicle-projectile" unit of today is a great deal more difficult to detect, especially if the aircraft is small and if therefore its surfaces of reflection are restricted. Approach warning will be unreliable, and the organization of the interception very complex. The issue of a fight between two moving bodies, each rushing along at transonic speed, will be decided in favour of the defensive only when reliable air-to-air and ground-to-air missiles have taken over the duties of interception from man, who would be crushed by gravity loads exceeding his power of physical resistance and whose nervous reactions would lag behind the requirements of supersonic combat. There will be an increasing tendency towards a defensive which will consist of attacking the enemy while he is on the ground. A combat aircraft spends nine-tenths of its life sitting on the ground. Thus, the fight will be carried between a moving body in the air and a "moving" body temporarily immobilised on the ground, rather than between two moving bodies in the air. This, in effect, is what the artilleryman calls "cross-battery". This con-

cept was evolved long before ballistics began to be more important in aviation than aerodynamics.

The air arm is now beginning to react against the "cross-battery" menace. While the air hates a vacuum, the air arm is beginning to abhor its long, concrete runways. Upon watching the Convair XFY-1 *Pogo* vertical riser one wonders why aviation has stuck so long to horizontal take-off and landing for high-speed operation, or to rotary-wings if it was prepared to put up with slow speeds and great mechanical complexity. The forward leap which the modern turboprop of favourable power/weight ratio has made possible today will be bettered tomorrow by the pure jet engine when its jet will be "tamed" by deviators or other control devices. There is no doubt that within the next ten years Bell, Ryan, Rolls-Royce and S.N.E.C.M.A., plus a host of others, will perfect flying machines modelled on today's American VTO aircraft but entirely jet-propelled. After that those vast cement-paved surfaces can be returned to the farmers—if the latter want them back—and all the helicopters can be assembled in the National Air Museum of the Smithsonian Institution, where they will provide tangible proof of man's ingenuity and compete with those collections of extinct species which were incapable of resisting the law of the survival of the fittest.

The "cross-battery" would then become a very difficult matter. The air arm would have succeeded in combining invulnerability in the air with invulnerability on the ground— provided the present trend does not reverse itself and destruction in the air by guided ground-to-air missile does not become easier than destruction on the ground. But it is probable that this "reversal of trend" becomes reality before the end of the period under consideration, i. e., before 1965.

Also before the end of this first ten-year period we shall see in flight machines combining jet reaction and thermo-propulsion. With a reasonable specific fuel consumption, speeds of 1,500 m.p.h. will be attained at an altitude of about 80,000 feet. Starting from launching ramps, ramjet-powered missiles will come into general use, with the low weight of its power plant offsetting the greater weight of the fuel supply.

1965 and After...

The nuclear-energy-powered aircraft will have passed from the test to the operational stage. What duties will it have? Weighing more than a hundred tons, capable of barely transonic speeds, what will be its military rôle?

First of all, it will have the advantage of a vast operating range, unlimited in comparison to terrestrial dimensions and, moreover, independent of operating altitude. It will be capable of crossing a continent at tree-top level, the only stresses to which it would be subjected being the altitude variations necessitated by the configuration of the ground. It would be difficult to detect a machine of this kind if the warning system were based on stationary ground stations. But the other use for this incredible range would be to parry the incursion of such hedge-hopping monsters. A permanent aerial early radar warning system could be set up with A-powered aircraft, and these machines would return to earth only once every week or every month, depending upon the endurance of the crews—in other words, upon the degree of comfort that could be offered to the flying radar men aboard their atom-propelled vehicle. The naval precedent, which is as old man's curiosity, seems to indicate that this use of the atom-powered aircraft should present no difficulties.

Will pilots board their aircraft by means of "fire-escape ladders" when V.T.O. aircraft have become common about ten years hence? Here the Convair XFY-1 vertical riser prototype.

But there is one domain in which the A-powered aircraft offers outstanding advantages —that of self-protection, provided by its virtually permanent motion in flight. Future bombers, even though they may take off vertically, would always be somewhat vulnerable when stationed at their bases. The same applies to remote-controlled or target-seeking missile batteries. The atom-powered aircraft, on the other hand, could stay in the air forever—or nearly—and thus escape the atomic sledge-hammer blows that would otherwise crush it on the ground.

In about twenty years' time, furthermore, missiles guided by celestial navigation and therefore incapable of being diverted from their trajectories by jamming operations (at any rate, at the present time, such a guidance system seems difficult to jam) will probably be filling the arsenals of the great powers. Perhaps they will also be provided with an animal-like "scent" enabling them to discriminate between a city and the surrounding countryside and seek out the former with unerring certainty.

Again in about twenty years' time, the earth may have been provided with several man-made satellites. But that is beyond the realm of aviation.

Militarily, there are two points worth noting. In a first phase of evolution, combat and military transport aircraft will abandon the horizontal take-off and landing method. Within the next five years the air arm will begin to disdain the cement surfaces, and within ten years it will dispense with concrete runways. In the course of a second phase and for certain specialized branches of the service, it will possibly seek invulnerability in the virtually permanent maintenance of its aircraft in flight. At that time the strategists will probably have the choice between a push-button guided-missile war and a "retaliation air police" engaged in a perpetual operational cruise.

The defensive can expect success only if it is equipped with air-to-air and ground-to-air missiles. An Oerlikon anti-aircraft rocket is being tested in Switzerland.

In the U.S.A. the Douglas-Aerojet *Nike* anti-aircraft rocket is being issued to A.A. units.

A New Era in Air Transport

It is surprising how many "eras" it has been possible to squeeze into the first fifty years of aviation's existence. There was the heroic era, the era of the monoplane, the four-engined era, the jet era, the rocket era . . . All of them were dictated by some aspect of engineering: the heroic era by the unreliability of engines and equipment, the jet era by the gas turbine, etc.

In air transport we now seem to be on the threshold of another new era, this one determined by the geographical *routes* the airliner will travel in future. As the earth's biggest land masses and the major industrial and population centres are situated in the globe's Northern Hemisphere, the shortest routes between widely separated points lead over the roof of the world, the Arctic regions. There is no doubt that, in the coming years, as instruments, navigation systems and ground radio stations are perfected, air transport will take increasing advantage of the *roundness* of our planet and travel the shortest distance from point to point by following the Great Circle routes.

On November 15th *Scandinavian Airlines System* officially inaugurated a regular twice-a-week Great Circle route between the Old World and the New, between Copenhagen and Los Angeles. One of the line's Douglas DC-6B's, the *Helge Viking,* took off from Copenhagen at 20:10 hours GMT and landed at Los Angeles at 14:18 hours local time next day, after a travelling time of 27 hours 8 minutes. This was a full five hours less than the time required to travel from Copenhagen to New York and across the U.S.A. to the West Coast (assuming, of course, that prompt trans-Continental connections are available at New York). The *Helge Viking* was crammed with celebrities—Prince Axel of Denmark, Prime Ministers Tage Erlander of Sweden, Hans Hedtoft of Denmark, Oscar Torp of Norway; outgoing S.A.S. President and pioneer Per A. Norlin, several other S.A.S. executives, and, of course, members of the press and radio. Refuelling stops of about one hour were made at Söndre Strömfjord on the West Coast of Southern Greenland, the Bluie West 8 of World War fame; and at Winnipeg, Manitoba, in the heart of Canada.

The flight was the culmination of long and careful development work by S.A.S. This included a series of route proving flights, the first of which was accomplished on November 20th, 1952;—the provision of special navigational aids and systems suited to Polar flying; the development of specialized Arctic survival equipment for passengers and crew in the unlikely eventuality of an emergency landing in the Far North; and of the creation of the necessary political circumstances making the regular operation of the route possible.

The last of these problems was more difficult to solve than one might imagine. In fact, S.A.S. encountered much trouble in its negotiations with the U.S.A. for Fifth Freedom rights at Los Angeles. However, since all three Scandinavian countries have long granted such rights to American operators, the U.S.A. finally gave S.A.S. traffic rights on the U.S. West Coast for an initial period of three years.

There is every chance that the Arctic routes will become busy air lanes in the future. Not only will American companies make full use of S.A.S. pioneering work and experience within the next few years by opening up their own services to Scandinavia and other points in Europe across the Arctic, but S.A.S. itself may be expected to apply its experience to other routes, primarily to its Far East operation. Here, of course, the company would have to fly a sort of "dog-leg" Great Circle course because the direct route would cross North-Eastern Siberia—a process which the Soviets would scarcely permit. But even under the present political constellation there is plenty of scope for commercial Arctic flying. Routes from the U.S. West Coast, the Pacific Northwest, even the Middle West to the heart of Europe, the Mediterranean area, Egypt, the petroleum regions around the Persian Gulf, all could profitably be laid over the Far North.

What would happen if—two, five, ten years from now—the Iron Curtain were raised, if American and European airliners were allowed to fly over Russian and Chinese territory, if Russian and Chinese transports were to fly freely to Canada and the U.S.A., is a matter of attractive conjecture. In the cold, calm, clear air of the Polar regions air transport would really come into its own. Aircraft flying from the North American Continent to Moscow and other Russian trading centres, to India, to the Southeast Pacific; airlines operating from Europe to China and Japan and vice-versa, would use the aerial highways across the Arctic.

Scandinavian interest in trans-Arctic flying dates back to the successful trans-Arctic flight of the Italian-built airship *Norge* under the joint leadership of the Norwegian Amundsen, the American Ellsworth and the Italian Nobile in 1926. Even before World War II other countries began to take an interest in trans-Arctic flying, especially the Russians. In this connection one merely has to recall the two successful non-stop flights made in 1937 by Chkalov from Moscow to Vancouver and by Gromov from Moscow to Los Angeles, as well as the unsuccessful flight by a four-engined Russian aircraft which intended to reach Mexico City but disappeared somewhere near the North Pole in the same year.

Today the air in the Arctic vibrates not only with the hum of commercial transports. Civil aviation has just begun to put in an appearance in the Northern latitudes, but the Polar region has preoccupied the military for some time. You need no traffic rights for a bombing run if war breaks out and the Polar routes would also be the shortest to the enemy's industrial centres.

The importance of the Far North in the present aero-political world picture will be debated in the February issue of *Interavia, Review of World Aviation.* Included will be an illustrated report on the first S.A.S. commercial flight along the Arctic route in which one of *Interavia's* Editors, P.A.B., participated on November 19–20th, 1954—appropriately enough aboard the DC-6B *Arild Viking,* the aircraft which exactly two years previously, on November 20th, 1952, had completed S.A.S.'s first trans-Polar proving flight.

← Intermediate landing at Söndre Strömfjord.

Visions of the Arctic from 13,000 feet.
A segment of Greenland's East Coast. →

"Fifty Years on" — Air Transport in A.D. 2005

BY PETER G. MASEFIELD, M.A., F.R.Ae.S., F. Inst.Ae.S., M.Inst.T.
CHIEF EXECUTIVE OF BRITISH EUROPEAN AIRWAYS, LONDON

Safety—speed—economy—reliability—comfort—range—those six features of air transport, as we know it today, all fall short of our needs and our desires. Those, I believe, are the requirements on which future progress will be fashioned. How far and how fast we shall go in achieving them only a "crystal ball" can tell.

Indeed, after fifty years of fantastic progress—of triumph and of disaster—in aviation's upward surge, an attempt to guess what the next half century may bring would be rash—beset as we are by the problems of the present. The words uttered by Edmund Burke 160 years ago in 1794, are as true today as they were then, and in no sphere are they truer than in that of aeronautics:—

> "To complain of the age we live in, to murmur at the present possessors of power, to lament the past, to conceive extravagant hopes of the future, are the common dispositions of the greater part of mankind."

They may indeed signpost the trends ahead. For, in those things of which we complain today and in those things for which we lament the past, we may well discern the aspirations and, hence, the achievements of the future.

When we look back for guidance over the past fifty years of aeronautics, the outstanding fundamentals are, first, the almost incredible increases in motive power and, second, the tremendous advances which have been made in structures, thanks to metallurgical progress. The increases in power and in the strength of materials have made possible the streamlined forms of today, which are propelled by compact engines of gigantic thrust. Those are the things which will continue and develop and change the form of aviation.

And the things of which we complain and for which we "lament the past?" Simplicity—short take-off—slow landings—quietness. Those four, outstandingly, we must seek to re-capture in the years ahead.

Fifty years is a long time in aviation. Even the possibilities of ten years hence are difficult enough to forecast. Let us remember that ten years ago the jet engine was still a novelty, known to the comparatively few. And let us recall that ten years ago no pressurized civil transport aeroplane operated anywhere outside the U.S.A.—and there only in small numbers.

But all the time from the past one can distinguish a continuous thread leading, through the present, into the future—a thread which strings together the results of man's endeavours to achieve advances in the assentials.

In air transport they are, I repeat, sixfold: safety—speed—economy—reliability—comfort—and range. They come in that order.

Therefore, looking ahead into the turbulent half-century to come, we can hope—and back that hope with a belief in man's ingenuity—that notable, even fantastic, advances will be made in those six directions.

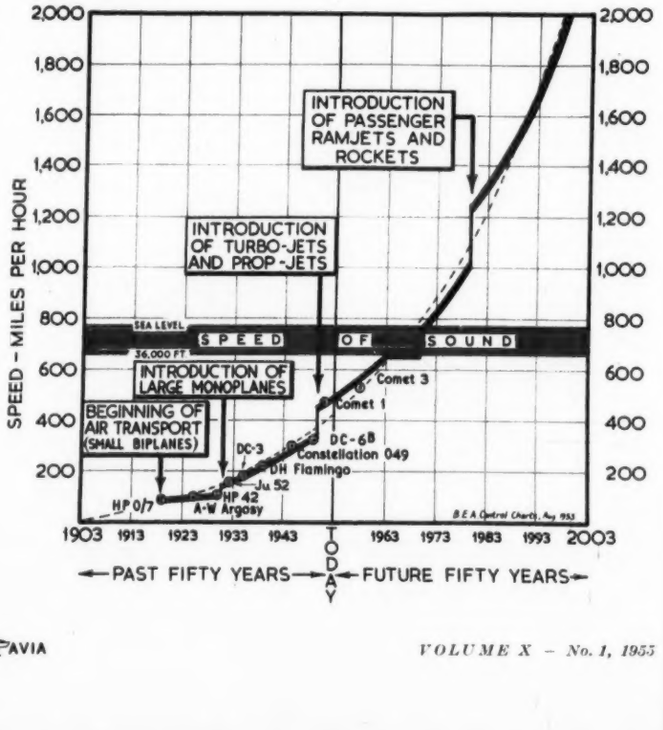
Safety, is, of course, the most desirable of all the objectives. Wilbur Wright is reported to have said "the only danger in flying is represented by the earth." Like the classic definition that—"a gentleman is never rude unintentionally—or violently", the essence of safety is that no flight shall ever return to earth violently—or involuntarily. So, in the course of the next fifty years we may hope that reliability of motive power will be a *sine qua non* and that take-off and landing aids, together with *en route* navigational aids, will have reached such a pitch of perfection that scheduled flights will be completed to timetable as a matter of course, whatever the weather. That implies, of course, take-off and landing in

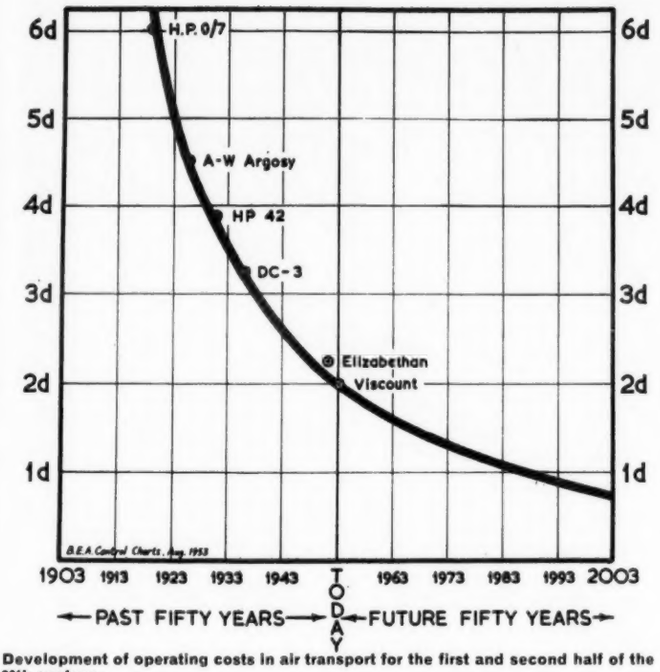
Increase in speed in commercial aviation during the first and second half of the 20th century.

This British European Airways diagram shows the average speeds of some of the most widely used commercial aircraft during the first half of the 20th century and the presumable rise in speeds up to 2003. A first major jump in speed came with the introduction of the modern piston-engined aircraft in 1930 (all-metal monoplanes such as the Junkers Ju 52 and Douglas DC-3). The second spectacular rise in the curve occurred when turbine-powered aircraft were placed in service. When the speed barrier has been pierced, which the author expects to happen in air transport about 1970, he foresees a powerful increase in speed through the introduction of ramjet and rocket aircraft (about 1980).

This diagram could be completed as follows:

1956: Douglas DC-7C (compound engines) 400 m.p.h.
1958: Douglas DC-7D, Lockheed L-1449 **Super Constellation** } (propeller turbines) 435 m.p.h.
1960: Boeing **Stratoliner**, Douglas DC-8, Lockheed } (turbojets) approx. 600 m.p.h.
2005: Douglas DC-70A, Lockheed "Super Cassiopeia" (!?) } 3,125 m.p.h.





Development of operating costs in air transport for the first and second half of the 20th century.

From 6d (7 cents) per passenger-mile in the 'twenties—Handley Page 0/7—operating costs per passenger-mile sank to half through the introduction of the DC-3. Today on short and medium-range services (Vickers **Viscount**), they are about 2d. The author expects them to fall to less than 1d per passenger mile by the year 2000.

"zero-zero" conditions and flights completed entirely on instruments from first to last, with automatic collision-avoiding devices affording perfect security all the way.

This quest for safety of service—satisfying the most basic of human instincts—must eventually *modify and change our take-off and landing techniques*. During the first 50 years of flying there has been no progress at all in this direction. Indeed, the Wright Brother's portable launching rail was in advance of the expensive devices to which we have since been driven, involving thousands of tons of concrete and acres of valuable ground.

The next 50 years must produce the answer to the problem which has bedevilled aviation since its start—how to get into the air and back to earth again, gently, quickly, surely and safely—and in the minimum of space.

I believe that the next *20 years* will produce this answer—and, *in the 30 years after that, vertical take-off and landing will become both reliable and economic*. Just as important, they must be made quiet so that services from the centres of cities will be not only tolerated, but welcomed.

In the long run the answer will not be the helicopter with its expensive rotor-blades, flapping, bending, twisting and vibrating. The answer will surely come either from a developed form of direct "jet-lift" or in a new realm of anti-gravitational electronic power. We shall then see airliners taking off vertically from air terminals in the centres of cities and returning again "down the spout" with, we may hope, the precision of clockwork trains.

Linked with this ability to operate directly from the traffic centres goes *the need for speed*—the commodity which, above all others, air transport has for sale. In 50 years we have progressed from the 30 m.p.h. of the Wright Brothers to the everyday cruising speeds of better-than-300 m.p.h. —a tenfold increase. But this is not enough. No seat yet made remains comfortable to the human posterior for more than about three hours at a stretch. The simple and logical requirement, then, is that *any terrestrial destination should be reached within the "comfortable sitting time."* Stretching this to, say, four hours—a "between meals" measure—and matching that period against the longest inter-city distance on earth—12,500 miles—we reach a required, non-stop, block speed of 3,125 m.p.h. I see no reason why this speed should not be achieved, economically, within 50 years or a little over. "Sound barriers," "thermal curtains," and the like, need present no immutable impediment to speed in aeronautics. How it may develop is set out in the curve.

The speed problem, once again, is basically metallurgical, first in securing the power and then in applying it safely and economically. Nuclear propulsion will certainly be with us on a major scale within the next half-century—and other, even more revolutionary means of motive power lie ahead!

Vertical take-off and landing and better-than-Mach 5 cruising speeds—maintaining the 10-to-1 ratio of increase over 50 years—must be achieved with economy. Again we look to the power-plant to achieve it.

Today, turbine engines with and without propellers are beginning to drive out the piston engine. In 20 years, at the most, that elimination will be complete. In one form or another, I feel certain that in 20 years the internal-combustion turbine will be well on the way towards obsolescence. A new, light motive power of the future, consuming very little fuel, can be the biggest step forward towards low costs combined with hyper-sonic speeds.

In this category also comes range. The ultimate we need, terrestrially, is 12,500 miles. We shall get it—and within 50 years, I believe, with payloads as large as we need them.

Finally, *comfort*. Comfort and speed are to some extent interchangeable, in a four-hour flight, cocktail lounges are hardly necessary. Even so, a little room to move around has its advantages. I believe that, after the accelerations of take-off and initial climb are over, we shall find that the cabin of the hyper-sonic aeroplane will be made large enough for free circulation as a change from those "four-hour" armchairs.

What then, is the picture? Given peace, I believe that by the dawn of the Twenty-First Century we—or our grandchildren—will see large airliners flying silently and safely, with precision in all weathers, between city centres from 50 to 12,500 miles apart. Over the longer distances, speeds of 3,500 m.p.h. and more will be scheduled, on the shorter sectors the dictates of acceleration and deceleration will hold speeds down to rather less. Economics? Costs are always disappointing. But air travel fares will, doubtless, stabilise at no more than those of surface travel. In some ways the problem of the air are easier than those which remain in speeding congested surface transport.

Yet, "dipping into the future" is full of pitfalls. One can state only an expression of faith—faith both in the ingenuity of mankind and in the opportunities which Aeronautics provide.

That great pioneer, Louis Paulhan wrote, in 1910—nearly 45 years ago:—

"One of the most dangerous things to do in flying matters is to set up as a prophet. Men who have done so have lived to regret it. Someone was ready, I am told, to bet the sum of a million pounds that the flight from London to Manchester would never be made by aeroplane. But it was made—as I have reason to know. Personally, I do not think the aeroplane is likely to be used as a general carrier of goods. In this respect land transit will, I believe, hold its own. But for carrying mails over difficult or variable country the aeroplane should be of very great use. I cannot see the aeroplane ousting land traffic altogether in regard to passenger-carrying and the carrying of merchandise. But I do expect to see regular passenger services through the air in operation when we reach the year 1920.

"Man has already achieved a partial triumph over the air. When he has made this partial triumph complete, the World will find that it has, in the air, a swift and sure means of transit. The commercial field which will be opened up by the aeroplane will be much more important than was that produced by the motor car."

These words of prophesy by a great aeronaut of 1910 can hardly be improved upon today.

Atomic Energy — the Power of the Future

"Obviously from a military point of view atomic aircraft are valuable because, like atomic submarines, their range is limited only by human factors. As a bomber, an atomic aircraft could select its target at will, even if this meant a change of many thousands of miles from its original destination. As a radar station it could detect hostile troop movements or air attacks on a round-the-clock basis, freeing conventional planes for other operations.

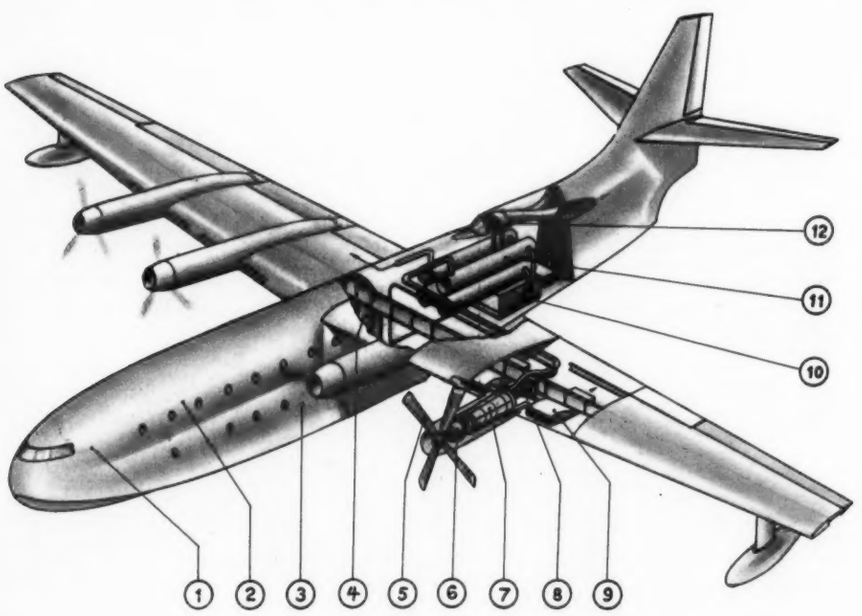
"Though its military worth as a deterrent to aggression seems inestimable—its peaceful applications, I feel, are equally boundless. I expect to see in my remaining lifetime fleets of commercial atomic passenger and cargo planes, flying at speeds fantastic by present-day standards, free of fuel problems and providing cheap, comfortable transport between points fixed only by the dictates of commerce. The atomic airplane will certainly prove out the dual destiny of the atom—to deter, and to create."

These words where spoken by *John Jay Hopkins,* Chairman and President of General Dynamics Corporation, New York and thus head of this organization's subsidiary divisions: Convair, Electro Dynamic, General Atomic, Electric Boat and Canadair Limited, Montreal. Hopkins, who was speaking in Philadelphia, Pennsylvania, on October 26th, 1954 to members of the Poor Richard Club . . . by no means "poor men" but leading United States industrialists and financiers, knew what he was talking about, as his companies are not only playing a leading part in the building of the U.S. Navy's first two atomic submarines (*Nautilus* and *Sea Wolf*) but also concerned in development work on an atom-powered aircraft.

John Jay Hopkins, Chairman and President of General Dynamics Corporation, recently gave an address in Philadelphia, Pennsylvania, on "A Philosophy for the Atomic Age." His group of companies is building atomic submarines and working on a project for an atomic aircraft.

Will America's first atomic aircraft be a landplane or a flying boat? Will it be propeller or jet driven? — These are questions to which no reliable answer can be given at present. The project and development work that has been going on for some years at *Convair, Lockheed* and *Boeing,* who are all working on atom-powered airframes, is still shrouded in secrecy. The same veil also hides the work of *General*

Will the first atomic aircraft be a propeller-driven flying boat? Drawing shows: 1 – pilot cockpit; 2 – upper passenger deck; 3 – lower passenger deck (or cargo space); 4 – radiation shield (simultaneously main bulkhead); 5 – propeller; 6 – reduction gear; 7 – steam turbine; 8 – condensation return pump; 9 – waste steam condenser; 10 – atomic reactor with control system and radiation shielding; 11 – heat exchanger battery (four high-pressure water-tube boilers) for conducting heat from the "primary" exchange medium (lead-bismuth mixture) to the secondary working medium (water); 12 – ventilation and cooling system of the atomic energy centre. – *Interavia drawing strictly copyright.*



Survey

of the organizations and firms engaged in the American development programme for atomic power plant and aircraft.

A.E.C. (Atomic Energy Commission), in particular the Oak Ridge National Laboratory, Oak Ridge, Tennessee, for **radiation shielding** and investigations on **reactor materials** and **heat exchange media.**

N.A.C.A. (National Advisory Committee for Aeronautics), in particular its Lewis Flight Propulsion Laboratory, Cleveland, Ohio.

U.S.A.F. and A.E.C., who are jointly erecting a **ground test installation** for atomic aircraft power plant in conjunction with the National Reactor Testing Station at Idaho Falls, Idaho (cost $33,000,000; operational by 1955).

General Electric Company began work in 1951 on aircraft reactors—after taking over Fairchild installations for the N.E.P.A. project (Nuclear Energy for Propulsion of Aircraft)—and has set up a special department for aircraft nuclear propulsion. The A.E.C. is to provide a total of $5,600,000 for General Electric's development work during the 1955-56 fiscal year.

Pratt & Whitney Aircraft Division (United Aircraft Corporation) has been working since 1953 on an alternate **engine programme** to General Electric's. The A.E.C. is to subsidize Pratt & Whitney's work to the tune of $8,600,000 in the 1955-56 fiscal year.

The Glenn L. Martin Company: preparatory studies on atomic reactors.

Union Carbide and Carbon Corp.: atomic engine programme.

North American Aviation Inc.: radiation research and preliminary studies on reactors. Plans for a $10,000,000 reactor at Santa Susana, California.

Philipps Petroleum Company: operation of a material testing reactor for the A.E.C. at Idaho Falls, Idaho.

Convair Division (General Dynamics Corp.): development work since 1951 on an airframe, under U.S.A.F. contract, to be fitted with General Electric atomic engine; test reactor in operation at Fort Worth, Texas. Electric Boat Co., another of General Dynamics' companies, is building—in conjunction with other firms—the U.S. Navy's first two atomic submarines, the **Nautilus** and the **Sea Wolf.**

Lockheed Aircraft Corp.: several years development work on an atomic airframe.

Boeing Airplane Company: development work since 1952 on an atomic airframe, presumably for Pratt & Whitney power plant.

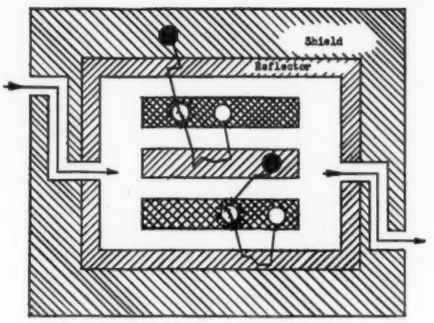
Electric and *Pratt & Whitney*, who have set out to develop lightweight atomic reactors, atomic heat exchangers and fluid flow machines.

However, *Interavia's* technical editors feel that the first atom-powered aircraft will most probably be a flying boat and be propeller-driven; their idea of a possible propeller-driven atomic aircraft is illustrated on the previous page.

In the drawing, the *atomic reactor* (10) forms the source of power for the whole flying mechanism. In the reactor the fissionable heavy metal (uranium 235 or plutonium) breaks down through a slow, controlled chain reaction into barium, krypton and other medium heavy elements, during which process about $1^0/_{00}$ of the mass "disappears," i. e., is converted into heat, gamma rays and neutrons. With full utilization of these energies—which, however, may never be possible—one pound of uranium 235 would produce the same "heating value" as 1,000 tons of aviation gasoline. However, even a 20% utilization, i. e., the counterpart of 200 tons, would suffice to take a flying boat, weighing 100 to 200 tons once round the globe non-stop.

In order to transfer the released heat from the atomic reactor to the fluid flow machine and at the same time to maintain a carefully chosen working temperature in the reactor itself (as otherwise it would "die" or turn itself into an atom bomb), a *heat exchange medium* is required. This medium must have a sufficiently high boiling point (above 1,000° C), so that it is not necessary to make the atomic reactor capable of withstanding high pressures, and the lowest possible freezing point. It must also be ensured that the heat exchange medium should "swallow" very few neutrons as it passes through the reactor, as it would otherwise make the other parts of the engine radioactive. Water, which boils at 100° C under normal pressure conditions, is therefore scarcely suitable as a "primary" medium—between the atomic reactor (10) and the heat exchanger (11). On the other hand good results appear to have been achieved with *lead-bismuth mixtures* (melting point below 100° C, boiling point above 1,000° C) at the National Advisory Committee for Aeronautics' Lewis Flight Propulsion Laboratory. However, water, or water vapour, would seem to be quite suitable as "secondary" heat exchange medium, for example for heat transfer from the heat exchanger (11) to a steam turbine (7) to drive the propellers.

If, however, the working temperature of the atomic reactor cannot be raised to *substantially* more than 1,000° C, the available heat differential suffices only to operate steam turbines for propellers, but not turbojet or rocket engines. Propeller propulsion also has the advantage that the atmosphere is not polluted by radioactive gases.



Structural diagram of an aircraft atomic reactor according to A. Kalitinsky (formerly Chief Engineer to Fairchild's Atomic Energy Division): the fast neutrons emitted by the *fissionable uranium 235* (cross hatched) are slowed down by the *moderator* (simple shading, e. g., of graphite) and returned to the pile by the *reflector* (e. g. also of graphite), to initiate new fissions. The chain reaction is controlled by neutron absorbers (e. g. boron steel rods; not shown here) which are pushed in or out in fine stages by a control device. Impurities in the moderator (black spots) can also capture the neutrons. Arrows show the direction of flow of the "primary" heat exchange medium (e. g. liquid lead-bismuth mixture) which conducts the heat released during the chain reaction to the working medium of the engine (e. g. steam). A thick radiation shield captures escaping neutrons (upper black spot) and screens off the gamma rays.

Finally, ample provision is made, as can be seen from the drawing, for protecting the aircraft's occupants and the ground maintenance crews from radiation. Even a few hundred Röntgen units of gamma rays and a small number of "escaped" neutrons are "fatal doses" for man. This problem also appears to have been solved now, as Hall L. Hibbard (Vice-President, Engineering, of Lockheed Aircraft Corp.) told the U.S. Air Force Association on April 24th, 1954. On the one hand the atomic reactor (10) is directly surrounded by lead walls (against gamma rays) and cadmium and concrete walls (against neutron radiation), and on the other there is a similarly constructed compound radiation shield (4) to screen the aircraft's occupants from any residual radiation.

Concrete, lead and cadmium are obviously not exactly lightweight materials. For this reason alone the gross weight of the first atomic-powered aircraft will doubtless be very high—estimated at between 100 and 200 tons—so that a flying boat would seem to be the best solution, since it needs no fixed runways.

The Air Hostess Told Us...

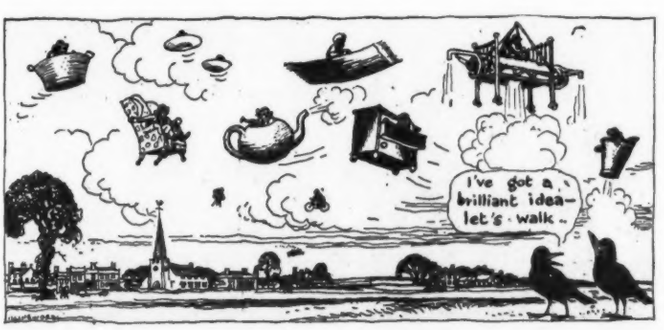
I am, says Esmeralda, getting old. Come, come, one is as old as one feels, we counter, think of Madame Roosevelt. That's just it, says our Favourite Air Hostess. I *feel* old, the dreams of my childhood, the things I knew in my youth, are slipping away one by one. Now I've just lost one of the early games we used to play...

Do you remember, she pursues, nostalgically rolling those beautiful eyes to the ceiling, how we kids used to sit around the table on wet winter nights shouting, "the eagle *flies,* the swallow *flies*,... the chair *flies*," and so on in rapid succession. You raised your arms for those things that really flew, kept them down for those that didn't, and if you made a mistake you paid a forfeit.

Those were the days, she proclaims, now they are gone forever. *Today everything flies.* The bedstead *flies*—up with your arms; the cigar *flies*—up with them; the stovepipe *flies,* the saucer *flies,* everything flies, and our old game is finished because the kids would die of physical exhaustion shoving their arms up into the air.

Keep your hat on, honeybelle, we say. There's a compensation in everything. Soon the air will be so crowded with identifiable and unidentifiable flying objects that if you shout, the sparrow *flies,* the crow *flies,* and even, the *Fly flies,* you don't pay a forfeit if you keep your arms on the table. They'll all be walking.

"I've got a brilliant idea – let's walk". – By courtesy, "Daily Mail," London.



FOUGA

CM. 170 Magister
a standard
N.A.T.O. trainer

Among the many official decisions whose application has been postponed or abandoned for one reason or another would appear to be the one made by the United States Government in 1954 that the training of foreign pilots by the U.S. Air Force was shortly to be discontinued, and that each European N.A.T.O. country should train its own pilots by the most up-to-date methods.

What are these methods? A student pilot is still a student though possibly he is today somewhat more highly gifted,—since higher standards are applied in initial selection. The final goal of today's military pilot is that he should be able to master an aircraft of supersonic speed, with a wing loading of more than 72 lbs./sq.ft. and a landing speed of more than 180 m.p.h., not to mention the complexity of its equipment. Consequently military staffs have been considering whether it might not be possible to speed up and improve training by putting students on to jet aircraft right from the start. This principle was accepted by N.A.T.O., the specifications of various types of jet trainers were checked and finally, on July 22nd, 1954 a kind of comparative demonstration of models from the United States, Great Britain, Canada, France, Holland and Italy was organized at Villacoublay military airfield, near Paris. Then in August the training committee of the Military Agency for Standardization met in London to decide on the suitability of those jet trainers that could be available within the near future.

In this investigation three classes of training were defined: Basic training, advanced training and conversion training to combat aircraft of the most varied categories. And when all the trainer types had been demonstrated and closely examined, the N.A.T.O. committee recommended at the end of November France's Fouga CM. 170 twin-jet trainer for the first two classes of training. An order for 100 of these aircraft had already been placed by the French Air Force before this decision was announced, and flight testing was practically finished. The decision of the London committee therefore opened up prospects for the French manufacturers of selling the type to other N.A.T.O. countries as standard model for basic and advanced training.

*

General design principles: Two-seat configuration with seats in tandem, of low structural weight and medium power, with adequate altitude and speed performance. Suitable for all exercises modelled on the tasks of a modern jet fighter: navigation, instrument flying, target exercises with guns and rockets, bombing at high speed, formation flying.

Originally designed particularly for advanced training, it has a number of features which recommended it to the N.A.T.O. commitee.

Tandem arrangement of seats, which all instructors agree is preferable: the student sits in the aircraft's plane of symmetry, an advantage in target exercises and formation flying. The arrangement of instruments and control levers corresponds roughly to that found in a modern single-seat fighter. The student is accustomed from the start to being alone in a closed cabin.

— *High aspect ratio* to ensure good altitude qualities.

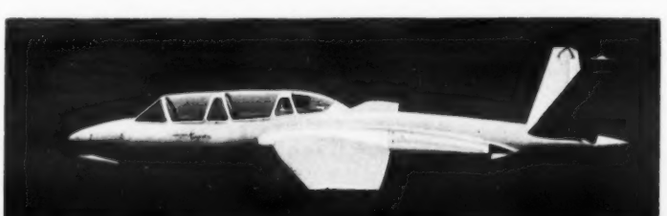
— *V-shaped tail unit* which, the makers contend, facilitates recovery from spins.

— *Short three-legged undercarriage* of wide track, which ensures good stability during taxying and reduces sensitivity to hard landings.

*

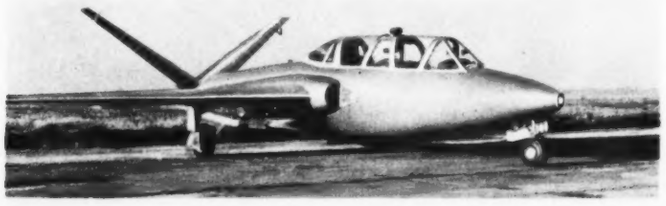
Technical description: cantilever mid-wing monoplane of high aerodynamic efficiency; trapezoidal two-piece wing unit with 13°

Good taxi stability and resistance to hard landings are achieved by means of the short, wide-track undercarriage.

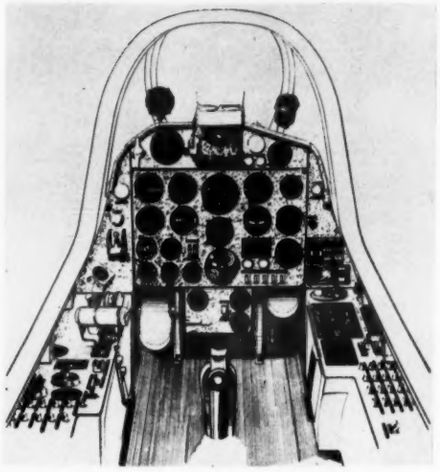


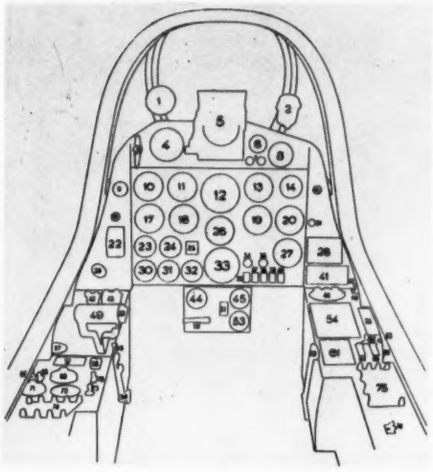
A fully transparent cabin roof gives excellent visibility for both student and instructor.

The low-slung fuselage simplifies maintenance of power plant and armament.

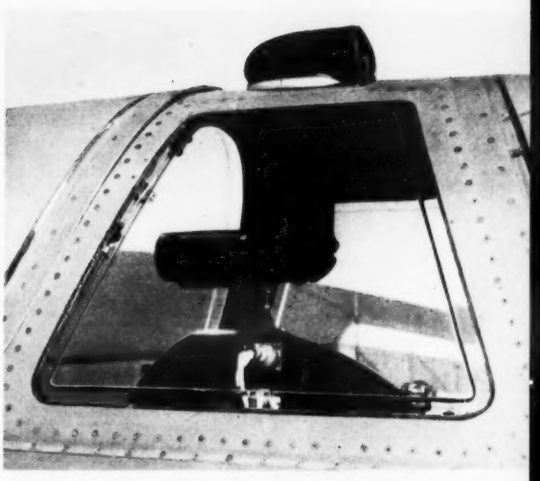


Most instructors agrees that the tandem arrangement of seats is preferable for the training of fighter pilots.





The arrangement of the instruments and equipment in the front cockpit corresponds generally to that of a modern single-seat fighter.



A SFOM periscope combined with the gyro sight enables the instructor to check the student during target practice.

1. Clock
2. Magnetic compass
3. Parking brake
4. Machmeter
5. Gyro sight
6. Pump for de-icing fluid
7. Fire warning lamp
8. Accelerometer
9. Warning lamp for undercarriage position
10. Revs. counter
11. Air speed indicator
12. Artificial horizon
13. Variometer
14. Fuel gauge
15. Fuel residue warning lamp
16. Fuel pressure warning lamp
17. Exhaust gas thermometer
18. Altimeter
19. Turn-and-bank indicator
20. Radio compass
21. Loading button for machine guns
22. Undercarriage operation
23. Indicator for undercarriage position
24. Oil thermometer
25. Switch for remote reading automatic pilot
26. Gyro compass indicator
27. Rheostat switch
28. Armament control switch
29. Indicator for elevator trim
30. Landing flap indicator
31. Oil pressure gauge
32. Cabin pressure indicator
33. Oxygen regulator
34. Generator warning lamp
35. Warning lamp for pitot tube icing
36. Generator switch
37. Battery switch
38. Switch for pitot tube de-icing
39. Switch for artifical horizon
40. Gyroscope switch
41. Selector switch for weapons
42. Emergency operation of spoiler flaps
43. Emergency operation of undercarriage
44. Pressure indicator for hydraulic circulation
45. Voltmeter
46. Switch for VHF R/T equipment (II)
47. Intercom. switch
48. Switch for radio compass
49. Throttle lever
50. Lever for spoiler flaps
51. Battery-generator switch
52. Adjustment of foot rests
53. Current meter
54. Switch board for radio compass
55. Switch for VHF R/T equipment (I)
56. Throttle lever lock
57. Cabin temperature regulator
58. Landing flap control
59. Low pressure cock
60. Hand pump
61. Intercom. switch
62. Starter
63. Starter control lamp
64. Quick release cock
65. Quick release cock
66. Lighting plug
67. Switch for landing floodlight
68. Switch for internal lighting
69. Light intensity regulator for instrument panel
70. Switch for landing and taxi floodlight
71. Rheostat for ultra-violet illumination
72. Indicator for aileron trim
73. Aileron trim tab control
74. Electric switch
75. Electric switch
76. Electric switch

leading edge sweep and aspect ratio of 7.4; NACA series 64 airfoil (with max. thickness at 25% of the chord), whose relative thickness decreases from 19% at the wing roots to 12% at the tips. Ailerons mass-balanced, with aerodynamic flaps and trim tabs. The wing also has slotted flaps which emerge from the wing upper and lower surfaces along axes parallel to the direction of flight, and landing flaps extending over half the span.—Wing unit of single-spar structure, with stressed light metal skin and auxiliary spar to carry aileron and landing flap fittings.

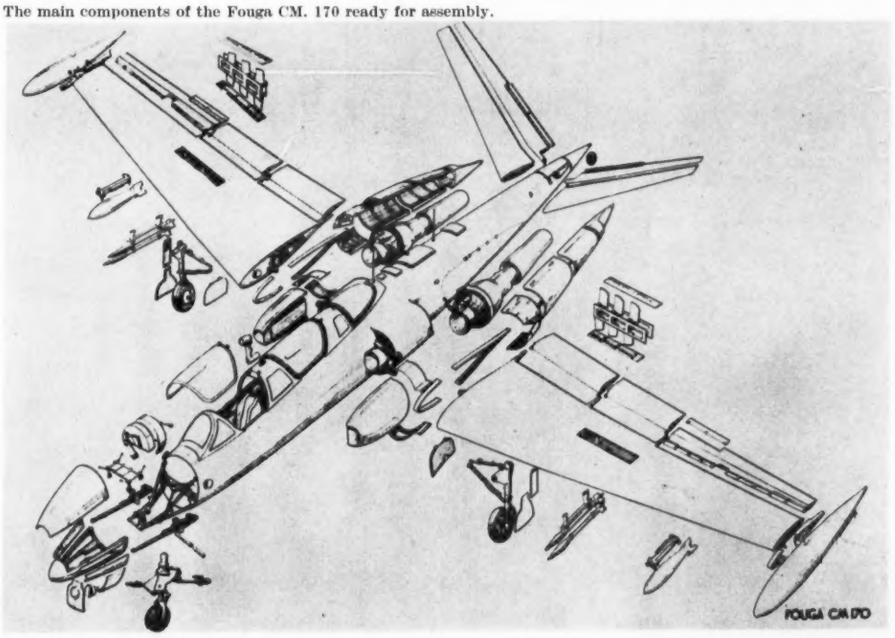
Circular section monocoque fuselage, stiffened by four longerons. A bulkhead in front of the cabin carries the support for the nose wheel and its hydraulic retraction mechanism. Two MAC machine guns, calibre 7.5 mm (.303 in.) are fitted, one on either side of the support, and are fed from two overhead 200-round magazines. Maintenance doors and removable skin panels provide access to the armament and equipment in the fuselage nose. Single canopy with good visibility for student and instructor; separate jettisonable roof over each seat for bailing out. Two fuel tanks with a total capacity of 160 Imp. gals., arranged symmetrically to the centre of gravity. The accessory relays driven by the two turbojets are in the fuselage and are accessible through removable maintenance panels.

Combined elevator and rudder unit in a V-angle of 110°. Aerodynamic balance through displacement of the axes of deflection of the two control surfaces, supplemented by mass balancing.

Main undercarriage units retracted hydraulically inwards into the wing bay between the main and auxiliary spars; nose wheel swings rearwards into the fuselage.

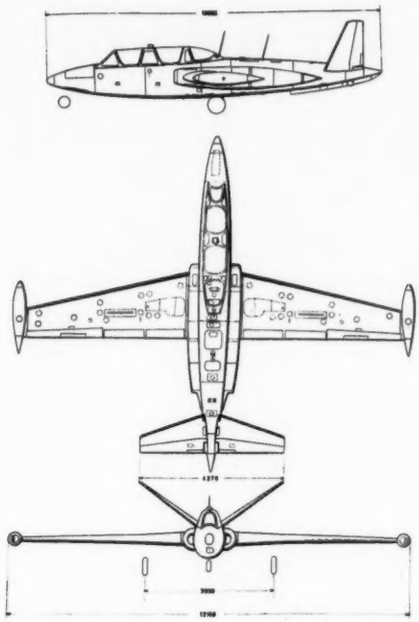
Power plant: Two Turboméca *Marboré II* turbojets of 880 lbs. s. t. each, one on either side of the fuselage behind the wing attachment. Removable cowling completely laying bare the engines. Air intake ducts projecting beyond the wing leading edge, and passing between the upper and lower trusses of the spar attachment segment. The fuel feed system permits of inverted flying for up to 30 seconds. Two auxiliary tanks, capacity 28.5 Imp. gals.

The main components of the Fouga CM. 170 ready for assembly.



Dimensions	
Wing:	
Span	37 ft. 1 in.
Length	32 ft. 9¾ ins.
Height	9 ft. 2¼ ins.
Wing area	186.2 sq. ft.
Aspect ratio	7.4
Tail unit:	
Span	14 ft. 4½ ins.
Height	4 ft. 11¾ ins.
Area: horizontal	40.4 sq. ft.
vertical	28.0 sq. ft.
Area of control surfaces	16.4 sq. ft.
Undercarriage:	
Track	12 ft. 5¾ ins.
Wheel base	14 ft. 9¼ ins.
Power plant	
Two Turboméca **Marboré II** turbojets	
Air mass flow	16.5 lbs/sec. at 22,600 r.p.m.
Pressure ratio	3.95 at 22,600 r.p.m.
Jet speed	1,670 ft/sec.
Max. outlet temperature	650° C
Dry weight	298 lbs
Static thrust	880 lbs at 22,600 r.p.m.
Consumption at s.t.	1.15 lbs/lb t.h.
Contin. power	705 lbs at 21,000 r.p.m.
Consumption	1.07 lbs/lb t.h.
Weights	
Wing	1,088 lbs
Fuselage	743
Controls	260
Tail unit	165
Undercarriage	458
Airframe	2,714 lbs
2 turbojets	690 lbs
Accessory drives	196
Power plant	886 lbs
Permanent equipment	665 lbs
Weight empty	4,265 lbs
Military equipment (excluding machine guns and bomb rack)	370 lbs
Crew	370 lbs
Fuel (excluding tanks)	1,320 lbs
Gross weight	6,325 lbs

Performance	
(for a mean take-off weight of 6,280 lbs.)	
Max. speed near ground	420 m.p.h.
Max. speed at 29,500 ft.	445 m.p.h.
Rate of climb near ground	3350 ft/min.
Rate of climb at 29,500 ft.	985 ft/min.
Climb to 29,500 ft.	16 min.
Service ceiling (rate of climb 198 ft/min)	39,370 ft.
Take-off run	600 yards
Landing distance from 50 ft.	875 yards
Range at 29,500 ft. (with 26 Imp. gals. fuel reserve)	570 miles
Optimum total endurance	1 h 55 mins
(for a mean take-off weight of 6,830 lbs.)	
Rate of climb near ground	2,950 ft/min.
Service ceiling	32,800 ft.
Take-off run	715 yards
Landing distance from 50 ft.	1,040 yards
Range at 29,500 ft. (with 26 Imp. gals. fuel reserve)	745 miles
Optimum total endurance	2 h 40 mins



each, mounted at the wing tips, increase endurance by about an hour.

Each of the two seats is fully equipped with instruments and controls, so that the instructor, in the rear seat, can constantly watch elevator trim, air brakes and landing flaps. Cabin ventilated and heated by warm air bled off the engine compressors, separate oxygen supplies with individual regulating valves.

Current is supplied to the electrical system by a 2,500 Watt generator and a number of accumulators with a total capacity of 35 Amp.-hours.

Radio equipment (at the back of the rear pilot's seat): a SARAM 5.52 VHF transmitter-receiver for 12 channels; a LMT-ERL 3401-C VHF transmitter-receiver for 3 channels, Lear A.D.F. 14-B radio compass. All equipment is operated from a single switch-board, to the right of the front pilot's seat. Intercom. between instructor and student.

Mk-IV-E gyro sights for both seats, with interconnected operation for instructor and student. A SFOM periscope attached to the rear sight enables the instructor to check the target approach.

Armament can be supplemented by the following military loads, depending on the training mission:

- four 9-cm or two 12-cm air-to-ground rockets, or
- two 110-lb. bombs suspended beneath the wings.

These weapons can be launched only from the forward seat.

A *table* shows the most important technical data for the Fouga CM. 170 and provides a guide to the efficiency of this twin-jet fighter.

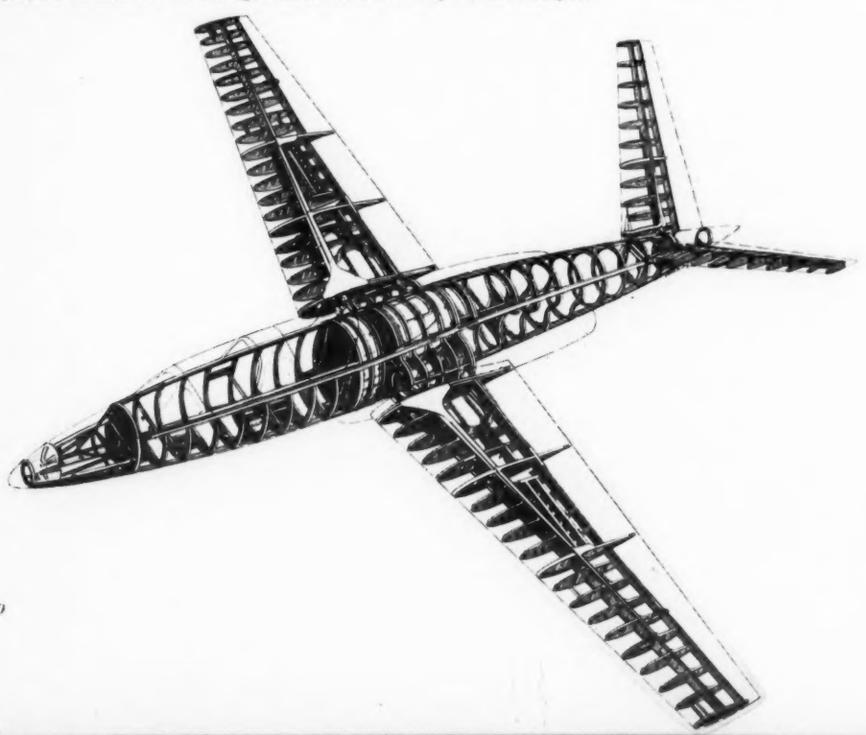
*

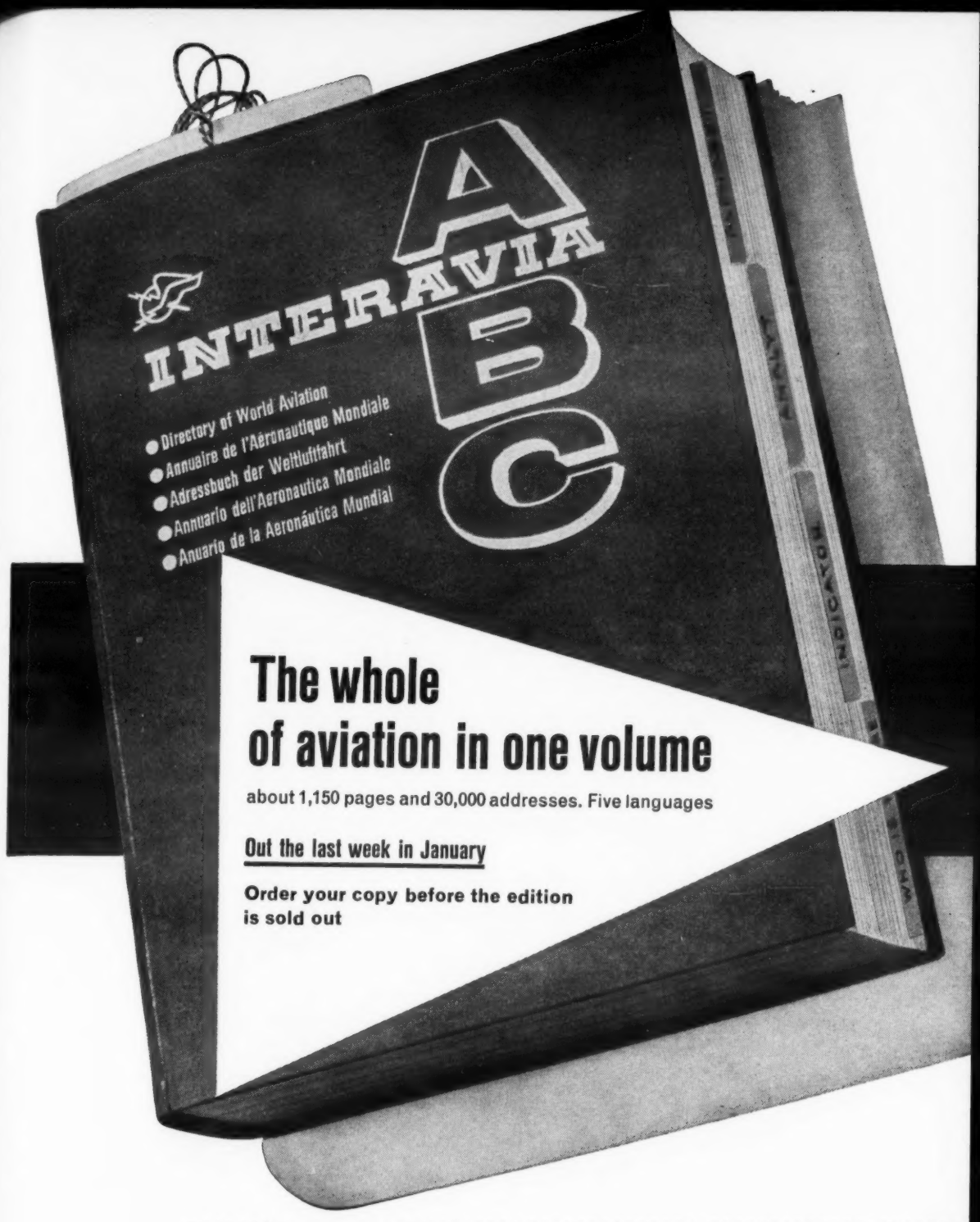
The London decision to recommend the Fouga *Magister* as a standard jet trainer for the N.A.T.O. countries is a considerable prestige success for the French firm of Etablissements Fouga & Co., of Béziers. Chief credit is due to Fouga's aircraft decision at Aire-sur-Adour. Pierre Mauboussin, creator and designer of the *Magister,* has thus been given recognition of the correctness of his design ideas. If the *Magister* is introduced in other N.A.T.O. countries, this will be a fitting crown to many years of effort.

The manufacturers, said Chairman Chasles to a press conference, regard the situation with optimism. He again stressed the economic solution provided by the *Magister,* since it can be used for both basic and advanced training, and expressed his thanks to the firms and individuals who had contributed to the success: for the power plant to Turboméca and its President Szydlowski, for the undercarriage Messier and its President René Lucien, not forgetting Henri Froustey, Managing Director of his own firm, or Pierre Mauboussin and his staff.

It therefore seems as if N.A.T.O.'s choice for basic and advanced training has now been made. The question remaining open is that of the type to be used for conversion training to combat aircraft. Here American, Italian and Dutch aircraft are close rivals.

Static structure of the Fouga CM. 170: two-piece wing unit with main and auxiliary spar; monocoque fuselage with four full-length longerons and approx. 30 bulkheads; two-piece V-shaped combined tail unit with main and auxiliary spar; the bulkheads in the fuselage centre section also carry the two turbojets.





The whole of aviation in one volume

about 1,150 pages and 30,000 addresses. Five languages

Out the last week in January

Order your copy before the edition is sold out

Fill in the attached order form and send it to your nearest INTERAVIA representative or to your book-seller

ORDER FORM

INTERAVIA ABC

Please send

..... cop. INTERAVIA ABC, 1955

Price: $12.00 £4.0.0 Sw. Fr. 50.—

☐ Check enclosed ☐ Please bill

Name:* .....

Address:* .....

Date: ..... Signature: .....

* Please write in block letters

INTERAVIA ABC

Please fill in the address

The Mechanics of Flow on Annular Wings

BY DR. WILHELM SEIBOLD, B.T.Z,, BRUNOY

Dr. Wilhelm Seibold, born in Künzelsau, Württemberg, on March 16th, 1912, studied physics and mathematics at Stuttgart and then joined Professor Georg Madelung's research institute, later known as the "Forschungsanstalt Graf Zeppelin" (Graf Zeppelin Research Institute=FGZ), in Stuttgart. After the war he worked as research and development engineer for the French Navy and for Arsenal de l'Aéronautique, an Air Ministry prototype firm. Since 1950 he has been working with von Zborowski at the latter's Bureau Technique Zborowski. Editors.

The following article deals in essentials only with those annular-wing aircraft in which the power plant is combined with the wing unit to form a single unit, i.e. the aircraft known as coleopters (French patent 1,050,948). In this configuration the housing of the power plant simultaneously forms the lift-producing element, either as a duct for a propeller, or a jacket of a ramjet engine, or a combination of both (French patents 1,033,589 and 1,051,259). The close coordination of power plant and wing unit provides certain distinct advantages, but also creates new technical problems, which will be discussed below from the point of view of flow mechanics.

Advantages and disadvantages of the annular wing

The annular wing will first be examined as a pure wing unit, i.e., without simultaneous use as power plant. It offers a number of advantages, in particular, to vertical take-off aircraft —with small span—though these are counterbalanced by the disadvantage of greater drag in a wide range of application.

Aerodynamic symmetry : A rotationally symmetrical body with annular wing mounted coaxially need make no roll movement before initiating a turn, but can begin the turn immediately. As is known, rolling speed is a measure for manoeuvrability, especially in a high-speed aircraft. The annular-wing aircraft is equivalent in this respect to a plane-wing aircraft of infinitely high rolling speed, as it always has the roll position needed for the initiation of a turn.

The importance of aerodynamic symmetry is illustrated by the many missiles with cruciform wings. In these configurations an approximately rotational symmetry is obtained as regards air forces by doubling the wing unit. In the cruciform-wing design, therefore, wing weight is doubled and drag increased without increase in lift, solely to obtain aerodynamic symmetry, i.e., to improve manoeuvrability and simplify control.

The annular wing has the advantage over the cruciform wing as regards both weight and drag, an advantage which becomes considerably more pronounced if the shape of the central nacelle and the annular wing in machines with constant supersonic speed is selected on *Busemann's* principles, so that the impact wave resistance is substantially reduced.

Aero-elastic oscillations : In the plane-wing aircraft aero-elastic oscillations present a very serious problem. Quite apart from the deformation of the individual airfoils in themselves, a plane wing has two other degrees of elastic freedom, namely the flexing of the wing (attached to the fuselage as a cantilever beam) and the elastic twisting of the airfoils in relation to one another. Such elastic deformations of the wing, however, cause changes in the air forces, and oscillations may occur which create difficulties in the steering of the aircraft and may, in certain cases, lead to fatigue rupture. Despite extensive research, these oscillations cannot be quantitatively forecast with accuracy, and any resonance phenomena occurring must be overcome by changing the rigidity, i.e., by increasing or reducing the strength of the material by empirical means, at considerable cost.

The *annular wing* has a torsional rigidity several times as high as that of the plane wing, and it is practically impossible for its individual airfoil sections to twist in relation to each other. Moreover, because of the favourable distribution of the air forces about the annular wing, the bending moments arising are so small that possible changes in air forces cause only very minor deformations. Deformations in the actual airfoil sections are also unimportant. If the annular wing is not too short, the occurrence of disturbing aero-elastic oscillations is practically excluded because of its great rigidity.

Drag comparison : These aerodynamic and aero-elastic advantages are countered, however, by a distinct disadvantage, which has hitherto caused the annular wing to be generally regarded as unsuitable, namely higher frictional drag compared with a plane wing of the same lift and the same aspect ratio (the "aspect ratio" of an annular wing is taken as the ratio between its diameter and its length).

Fig. 1 compares the drag of an annular wing with that of a cruciform wing and a plane wing. It shows the annular wing to have lower drag than the cruciform wing and, in general, higher drag than the plane wing of the same aspect ratio : its drag in economic cruising flight—in the case of propeller-driven aircraft—is 25% higher than in the plane wing. At high speed, i.e., with smaller angles of attack, the ratio becomes even more unfavourable.

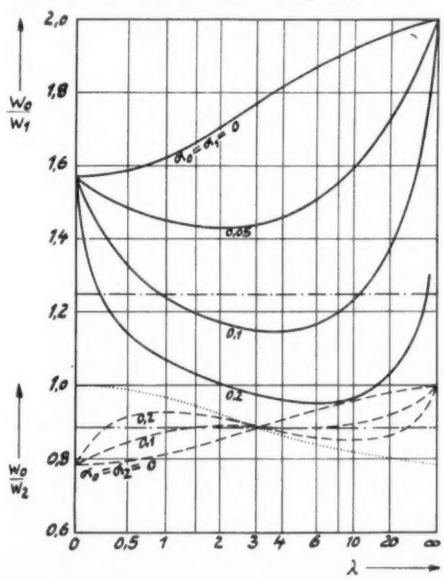
This disadvantage is more than compensated, however, as *von Zborowski* and *Hertel* have shown (see articles elsewhere in this issue) by the lower weight of the annular wing. For example, a propeller-driven annular-wing aircraft needs roughly 10% less fuel and only about half the structural weight as a vertical take-off plane-wing aircraft of the same transport performance (e.g., in ton-miles).

It is here that the necessity of regarding the problem as a whole becomes particularly clear, since the evaluation of a single detail—in the present case wing drag—may lead to entirely false conclusions.

The aspect ratio of a wing is *not* a decisive structural parameter ; it is therefore generally advisable to compare wings of equal span. Span is a parameter which plays a very large part in the unit weights of the structure and in manufacturing costs, as well as in the size of hangars etc. In vertical take-off aircraft span will have to be small : for example, even a span of 5 m must be considered "large" for a light high-speed subsonic aircraft.

Fig. 2 shows a drag comparison between two aircraft of the same weight, the same span (or wing diameter) and a given fuselage, one with an annular wing and the other with a plane wing. In this project the annular-wing aircraft is superior to the plane-wing aircraft for a span of up to 5 m, at any rate for angles of attack of a little over 5° and above.

Fig. 1 : Drag comparison between an annular wing (index 0), a plane wing (index 1) and a cruciform wing (index 2) of equal aspect ratios, for the same lift and speed and a friction coefficient of $f = 0.0025$. Angles of attack $\alpha_0 = \alpha_1 = \alpha_2$ are given in radians. ——— plane wing ; — — cruciform wing ; ····· limit curve for large angle of attack ; —·— flight at smallest lift/drag ratio.



Aerodynamics

Lift : *Lift derivatives* c'_a (derivation of lift coefficient c_a from angle of attack α, for $\alpha = 0$) for an annular wing in the *subsonic range*, in relation to wing frontal area $F = \pi/4\, D^2$, can be taken with sufficient accuracy from *fig. 3*, in which the influence of the Mach number has been taken into consideration according to Prandtl's rule. Parameter k of these curves is the so-called aerodynamic efficiency $k = c'_a \infty / 2\pi$. These curves represent theoretical values, which have been adequately checked by measurements at low Mach numbers.

No sufficiently accurate method of calculating the *position of the centre of pressure* has yet been published. A number of measurements made at very low Mach numbers have therefore been interpolated in *fig. 2*.

A central nacelle mounted coaxially with the wing reduces the latter's lift by a percentage equal to the ratio of nacelle cross section f to wing frontal area F (broken curve, *fig. 4*). *Fig. 4* gives the ratio of lift coefficient c_a of the wing-central nacelle combination to lift coefficient c_{a0} of the undisturbed wing alone. These curves represent an approximation for combinations in which the almost cylindical central nacelle projects beyond the wing leading edge by at least half the wing diameter D and ends shortly before the wing trailing edge.

The curves in *fig. 4* also give a rough approximation of the lift of not-too-short annular wings with reduced internal flow, when the cross section of the incoming air flow (at an infinite distance ahead) is subtracted from the cross section of the wing entry and then the difference in area thus obtained is added to nacelle section f.

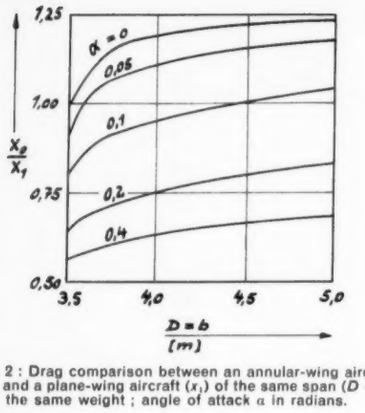


Fig. 2 : Drag comparison between an annular-wing aircraft (x_0) and a plane-wing aircraft (x_1) of the same span ($D = b$) and the same weight ; angle of attack α in radians.

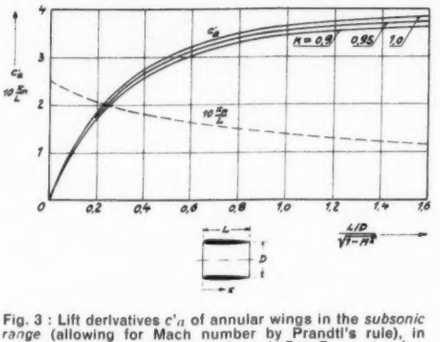


Fig. 3 : Lift derivatives c'_a of annular wings in the *subsonic range* (allowing for Mach number by Prandtl's rule), in relation to wing frontal area $F = \pi/4\, D^2$. Parameter $k = c'_a \infty/2\pi$ is the aerodynamic efficiency, x_n/L denotes the relative position of the centre of pressure.

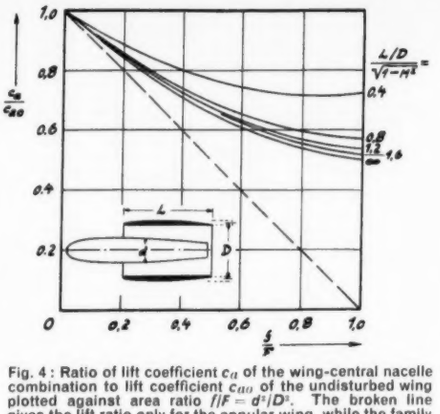


Fig. 4 : Ratio of lift coefficient c_a of the wing-central nacelle combination to lift coefficient c_{a0} of the undisturbed wing plotted against area ratio $f/F = d^2/D^2$. The broken line gives the lift ratio only for the annular wing, while the family of unbroken curves shows the actual lift ratio of the combination for various values of $L/D\sqrt{1-M^2}$.

In the *supersonic range* the lift derivatives can be determined with sufficient accuracy by well-known graphical and numerical processes, as can the c.p. position, though the latter only when flow inside the wing is supersonic. The latest publication on this subject is that of *S.F. Erdmann* and *K. Oswatitsch* (Zeitschrift für Flugwissenschaften, No. 8, 1954), which also contains an extensive bibliography. If, however, there is a subsonic flow inside and a supersonic flow outside, there is again no accurate method of pre-calculating the c.p. position, particularly for a wing with central nacelle, where the influence of the connecting arms between wing and nacelle is mostly important.

Whereas, in the supersonic range, lift always remains well below the maximum, in the subsonic range a top lift coefficient of about 1.3, in relation to the simple horizontal projection DL of the wing must be expected, for a wing of aspect ratio D/L of about 1 or less.

To increase stability, narrow guide surfaces can be mounted on the outside at the rear of the wing. These should preferably consist of prolonged coverings for the landing legs (cf. French patent No. 1,050,948).

Drag: The frictional drag of the annular wing with an angle of attack of zero can be calculated by the same method as for the plane wing. For slender airfoils it is practically equal to the frictional drag of a plane plate.

Induced drag coefficient c_{wi}, in relation to wing frontal area $\pi/4\, D^2$, is obtained in the subsonic region from lift coefficient c_a by means of the simple equation $c_{wi} = c_a^2/8$. Measurements show that a correction Δc_{wi} must be added : $\Delta c_{wi} = c \dfrac{L}{D} \alpha^2$, where α is the angle of attack. Constant c decreases with increasing Reynolds number and also depends somewhat on the shape of the airfoil. For a Reynolds number of 10^6, c is about 0.6. — In the supersonic range, as is well known, $c_{wi} = c_a \cdot \alpha$.

General power plant questions

As already mentioned, the annular wing in the coleopter simultaneously forms a jacket for the power plant. The close coordination of wing unit and power plant thus obtained makes it impossible to evaluate the wing unit solely on the basis of its aerodynamic lift and drag parameters. It should be added that the definition of " drag " in the self-lifting power plant is somewhat arbitrary. It is a frequent useful convention to allow for the losses on all parts of the power plant in the propulsive flow when calculating thrust, and to count as drag only the flow losses due to external flow, including the losses due to an oblique incident flow.

An evaluation of the power plant solely on the basis of its efficiency would also not fill the bill. If, in the case of the self-lifting power plant, efficiency is related to the *free* thrust (efficiency = thrust times speed divided by power expended), this inevitably gives a very small value in unaccelerated flight, as such a power plant need deliver no free thrust apart from the equivalent of the induced drag.

Basically, therefore, only an *overall evaluation* is of value for a self-lifting power plant ; i.e., the question of total fuel and structural weight for a given flight task. In other words, the question is the economy of the whole device. An examination of the flow mechanics provides some of the information needed, but not an independent criterion.

Ducted propeller

For the calculation of the ducted propeller it can be assumed that the air stream runs parallel to the axis at its exit, and has external pressure. However, if the shape of the nozzle produces a different type of slipstream, there are thrust losses on the power plant. The optimum condition will therefore always be aimed at in designing the power plant.

If the exit area of the duct is equal to the propeller disc area the ducted propeller at *high* speeds of flight has merely an *insignificantly higher thrust* than the free propeller, (with the thrust of the power plant calculated without deduction of the frictional losses on the wing unit). For this reason, as much as because of the drag and weight of its duct, the ducted propeller has been tried, but not applied, in aircraft design. *Only when the duct is also used as wing unit—as in the B.T.Z. aircraft configurations—is the ducted propeller of great advantage.*

An *increase* in the exit area might give an increase in thrust, but this is frequently not obtained in practice, as the boundary layer as a rule breaks away behind the propeller and does not return to position in a widened duct.—*A reduction* in the exit area reduces thrust, but has the advantage of lower speed in the propeller plane. However, this advantage is small. —On the other hand, such a reduction is often advantageous for subsequent heating of the propulsive stream.

The essential advantage of the ducted propeller is its high static thrust S_m, which can be calculated from the formula $S_m = (4\rho F)^{1/3} \cdot (\eta N)^{2/3}$ (ρ = air density ; F = exit area ; N = shaft power of the engine ; η = hydraulic efficiency). The latter is defined with the aid of mean pressure jump Δ_p on the propeller, mean speed v in the propeller plane and propeller disc area F_p as

$$\eta = \Delta_p\, v\, F_p/N.$$

For the *free* propeller, on the other hand, static thrust $S_f = 2\rho F_p)^{1/3} \cdot \eta N)^{2/3}$. The ratio of static thrusts, for equal shaft power of the engine and equal hydraulic efficiency, is thus :

$$\frac{S_m}{S_f} = 2^{1/3} \cdot \left(\frac{F}{F_p}\right)^{1/3}$$

If exit area F equals propeller disc area F_p, the static thrust of the ducted propeller is 1.26 times the thrust of the free propeller. This does not allow for the fact that in the latter there are—owing to unfavourable flow round the blade tips—losses in static thrust which exceed the slot losses and frictional losses in the ducted propeller. This shifts the static thrust ratio still further to the advantage of the ducted propeller.

Static thrust—it should be stressed—is of decisive importance in the design of an aircraft for vertical take-off and landing, as the static power required largely decides the weight of the power plant.

Ramjet power plant

The method of calculating the ramjet power plant is today sufficiently well-known, at any rate as far as the internal thrust is concerned. Some attention must, however, be given to the possibility of taking up thrust, particularly at the intake.

If the area of the incoming air stream is smaller than that of the engine intake, i.e., if a so-called free-flow diffusor is used, its efficiency in the subsonic range, with suitable shaping of the power plant leading edge, is considerably higher than that of a ducted diffusor. In the supersonic range, on the other hand, the free-flow diffusor suffers substantial thrust losses, which have not yet been fully calculated. Calculation of their upper limit, however, is relatively simple.

As the ramjet power plant in the coleopter is also used as wing unit (French patent No. 1,033,590), it is over-dimensioned and therefore needs only slight heating. This means that the flow speed at the entrance to the combustion chamber is distinctly high, corresponding in designs completed hitherto to a Mach number of about 0.3.

To reduce the difficulties arising here, especially at altitude, combustion is carried out in special burners, themselves working under ram pressure (French patent application P.V. 674,326). By altering the size of these burners it is possible to select the best fuel-air mixture for combustion and to obtain a considerable reduction in the speed of flow at the point of combustion. The leading edge of these burners, which receive subsonic flow, is in the form of a free-flow diffusor, as the latter on the one hand has a very high efficiency and on the other gives the burners a low air drag when the ramjet is cut off.

The projects already worked out are such that the pressure in the burner—up to altitudes of 10 km—is more than 1 kg/cm² and does not fall below 0.5 kg/cm² even at altitudes of up to 20 km, with the speed of flow corresponding roughly to a Mach number of 0.1. Good combustion can therefore be expected. The dimensions of the annular wing are also so selected that the coleopter flies at a very small angle of attack when the ramjet is burning—i.e., at high speeds of flight, so that the ramjet is not disturbed in its functioning (verified by measurements) and there are only small thrust reductions compared with the power plant at zero angle of attack.

Combination of power plants

If the annular wing is suitably designed it can also serve as jacket for a ramjet engine, which has special advantages when the aircraft is to have supersonic speed or when high short-period acceleration reserves are required in the subsonic range.

A ducted propeller with subsequent combustion is already one form of combination power plant.

The propeller gives the aircraft the necessary thrust for vertical take-off and permits of economic cruising flight at moderate subsonic Mach numbers. Short-period acceleration peaks can be obtained by subsequent heating of the slipstream, as the operation of the power plant—with increasing speed—rapidly approaches that of the full ramjet even with moderate heating. The use of a ramjet always requires a special take-off engine, as the ramjet engine delivers no static thrust.

If the aircraft is to be raised rapidly to high speeds, a rocket engine is best used. For a flight of only a few minutes duration or for supersonic flight at high Mach numbers, this gives the lowest power plant weight and costs (cf. also *fig. 5* to the article by v. Zborowski)—and hence a very light, cheap aircraft as a whole. If the rocket engine is suitably installed, thrust can also be increased by the air drawn along by the slipstream.

If the aircraft is required to cruise at relatively high altitude and at high subsonic speeds, a turbojet engine is particularly suitable. This engine can also provide the necessary thrust for vertical take-off.

Control surfaces

The coleopter has two systems of control surfaces :

The first system comprises *jet control surfaces*, which divert the propulsive jet stream of the take-off engine. They are used to steer the aircraft during take-off and landing and at low speeds. They also support the control surfaces of the second system.

– The second system consists of *aerodynamic control surfaces*, which in the coleopter should preferably be placed on the wing trailing edge and which become increasingly effective with rising speed of flight.

If the wing is used as a ramjet power plant, the aerodynamic control surfaces act on the engine jet stream on the one hand and on the external flow on the other. If two control surfaces on opposite sides are moved in the same direction, the engine jet is diverted ; if they are moved in opposite directions, they alter the exit area of the jet, which can be used to control the engine (French patent 1,050,948 and patent application P.V. 674,327).

If, for example, the ramjet engine is shut off at a high flying speed, there is a risk of negative pressure occurring inside the wing. To ensure that the wing does not buckle, it would have to be made much more rigid and thus heavier. To save weight, the exit area can be reduced by means of the control surfaces, so that at any rate no negative pressure arises inside the wing as a result of the reduced flow.

In propeller-driven devices one of the two systems of control surfaces can be dispensed with, as the surfaces at the end of the annular wing are always washed by the slipstream of the ducted propeller.

Conclusion

The annular wing can be used to advantage in vertical take-off aircraft, on the one hand because of its low structural weight, and on the other because it can also form a jacket for the engine.

When it is used as housing for a ramjet, it is possible to speak of a " wingless aircraft ", which has practically no air drag and therefore requires only small free thrust.

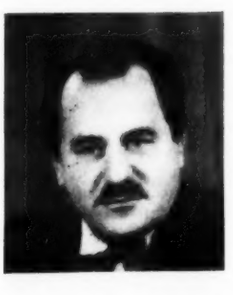
If the annular wing is used as a duct for a propeller, it again forms part of the power plant. In particular the static thrust is thereby markedly increased.

Even if it is used merely as a lift-producing element, it still has advantages. It is superior to the cruciform wing, and even to the plane wing for small spans. Other advantages are its complete aerodynamic symmetry and the consequent ease of control and high manoeuvrability of the whole device, as well as the elimination of all disturbing aero-elastic oscillations.

Finally, it must be stressed that no true comparison can be made between different wing configurations until the task to be performed has been fixed, and that when the annular wing is used as both wing unit and power plant the economy of the device as a whole is the deciding factor.

Structural Principles of the Coleopter Wing

BY PROF. DR.-ING. HEINRICH HERTEL, B.T.Z., BRUNOY



Professor Heinrich Hertel was born in Düsseldorf on November 13th, 1901 and studied at Munich and Berlin Technical Universities. In 1926 he joined the Deutsche Versuchsanstalt für Luftfahrt (German Aeronautical Research Institute), Berlin-Adlershof, then from 1933 to 1939 was Technical Director of the Heinkel works in Rostock and from 1939 to 1945 Technical Director, Chief Development Engineer and Board member of Junkers Flugzeugwerke, Dessau. The aircraft designed under his supervision include : He 100 record-breaking aircraft, He 111 bomber, He 176 rocket aircraft, He 178 (world's first jet aircraft, 1939), Ju 287 jet bomber (1944). Prof. Hertel also gave lectures at the Rostock and Brunswick Technical Universities. From 1946 to 1949 he directed the design of long-range high-speed commercial transports for S.N.C.A.S.E. (cf. Interavia *No. 8-9, 1950, pp. 463-472). He now works for Bureau Technique Zborowski.*

Editors.

Lightweight construction and economy

Vertical take-off is possible only when the aircraft's take-off weight is about 20% lower than the take-off thrust of its power plant. Hence, in such aircraft, lightweight construction is of decisive importance in determining their economy. Structural weight must be kept down to a minimum, so as to obtain the greatest possible fuel load and payload, i.e., high transport capacity. In addition to other advantages, the coleopter has important qualities in this very direction :

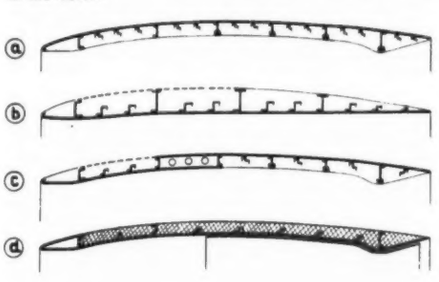
— its airframe is particularly suited to lightweight construction :

— in certain cases, such as when powered by propeller turbines, take-off thrust is substantially increased, without extra weight, by the duct round the air stream providing the forward thrust ;

— in other cases, as in the ramjet-powered coleopter, the annular wing serves as both power plant and wing unit. Here it is immaterial whether the saving in weight is booked to the airframe or the engine account. The important point is that total weight should be as low as possible, which can only be achieved if the unit's two separate functions are not mutually disturbing. Thus the high temperatures reached by the power plant may not greatly reduce the strength of the wing unit, nor the strength requirements for the wing limit the operating temperature of the ramjet or necessitate special cooling jackets.

Only a portion of the increased useful load obtained through the coleopter arrangement is absorbed by the somewhat higher fuel consumption due to the increased drag arising from the annular wing's greater area (compared with a conventional aircraft of the same weight). On balance, however, there is still sufficient surplus to provide extra payload and range.

Fig. 1 : Structural diagram of annular wings for coleopters : top to bottom : a— wing for a ramjet coleopter, in which the outer wall forms the stressed shell ; b— wing for a civil turboprop coleopter (inner wall = stressed shell) ; c— wing whose stressed shell changes over from the inner wall (front) to the outer wall (rear) ; d— future design for an annular wing with inner stressed shell and foam filling. — The broken lines indicate cut-outs for panels in the cover.



The tube as basic static system

The static advantages of the annular wing immediately emerge from a simple comparison :

— the classic wing is a " plane " configuration, a *plate* which becomes increasingly thin as it is developed towards supersonic speeds and must therefore be of very robust structure to take bending and torsion ;

— the annular wing, on the other hand, is a " three-dimensional " configuration, a *tube*, which has a high resistance to bending and torsion without particularly heavy construction.

If the annular wing is properly constructed, the air and mass forces are taken up and balanced " direct " by the tubular shell, so that no substantial bending moments occur. Calculations and design of an annular wing are

therefore based on the tube as the fundamental stress system.

In addition to minimum weight, minimum production costs must also be aimed at. Here the rotational symmetry of the wing offers distinct advantages. Moreover the airframe, despite its low weight and production costs, must have sufficient strength, stability and freedom from oscillations. The surfaces exposed to the air flow must be smooth and be proof against buckling in normal flight. This can be achieved by suitable design of the tube.[1] Finally it should be borne in mind that the annular space formed by the wing profile is used to house fuel, accessible equipment and payload.

Structure of the annular wing.

In itself, the thin wall of a tube would have neither stability nor rigidity to resist ovalizing forces, in particular at the support, where these forces are considerable. A thin-walled, but rigid tubular body therefore needs at least two " main " stiffening rings, e.g., one front and one rear ring, which can take up the support forces.

Local rigidity of the thin wall between the two main stiffening rings can be ensured either directly by means of subsidiary stiffening rings or indirectly by longitudinal members. A single-walled tube adequately stiffened by main and subsidiary rings forms a complete *stressed shell* [2] capable of taking up and transferring all air and mass forces.

However only one skin of the annular wing is completed as a stressed shell and dimensioned for rigidity and strength. The second skin merely forms a covering, braced to the stressed shell. This method offers the following advantages :

Lightweight construction : high rigidity and strength with low weights, as the stressed shell can have greater wall thicknesses and closer distances between the rings. The rigidity of a sheet increases, however, with the cube of its thickness.

Simple production : a single-wall shell is easy to manufacture, especially when rings are used as stiffening members (automatic spot welding). The covering skin can be made of longitudinal strips, which are easy to attach to the stressed shell, as their joints are not stressed *(fig. 1)*. On the other hand, an annular double shell, in which both walls were joined together by means of longitudinal and ring stiffeners to form a stressed unit, would be *difficult* to manufacture and repair.

Surface quality : Made of thick sheet and closely stiffened, the stressed shell can be regarded as " continuously rigid ", while the covering shell is not subject to high stresses. Both shells will therefore have high surface quality.

Utilization and accessibility of inside of wing : it is immaterial whether the inner or outer skin is constructed as the stressed shell ; it is even possible to pass from one skin to the other *(fig. 1c)*. Thus the designer has every freedom to leave the inside of the wing clear for equipment and payload or to fit retractable parts, as cut-outs in the covering skin do not reduce the wing's rigidity or strength.

*

[1] In addition, a process of blowing air into the wing profile has been developed (French patent 1,063,247 and patent application P.V. 52,226), by which local stresses and hence deformations of the wing shells can be kept to low values.

[2] French patent No. 1,087,825.

[3] French patent application P.V. 675,312.

[4] Additional French patent application No. 52,377.

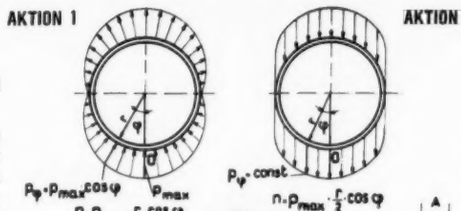


Fig. 3 : Lift and mass forces on the partial ring of a single-walled stressed tube for the coleopter annular wing.

Fig. 1 shows a number of different arrangements for stressed shell and covering shell :

In the supersonic coleopter with ramjet power plant *(fig. 1a)*, the *outer wall forms the stressed shell*, so that it is not directly subjected to the heat of the combustion chamber and can thus be made stress-carrying without using heavy heat-resisting material. The inner wall forms the covering. Free from static stress, it is used only to screen off the hot gases from the inside of the wing. It must, however, be capable of longitudinal motion, so as to avoid the otherwise very high thermal stresses, and can—towards the stressed shell—be insulated against direct heat conduction. As it is easily dismantled and replaced, it need not have the same life as the cold parts.

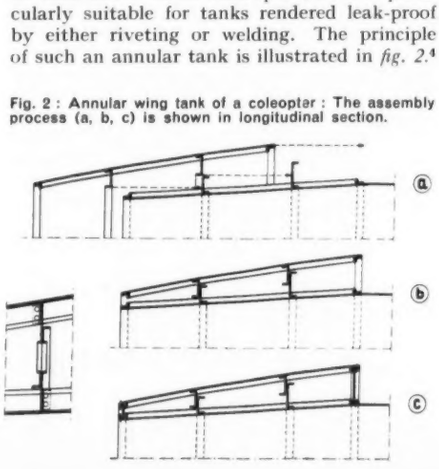
In the coleopter with propeller turbine, for example a civil aircraft or transport *(fig. 1b)*, the *inner wall forms the stressed shell*, as thanks to its cylindrical shape, it is easy to manufacture and has the necessary local rigidity to withstand vibrations caused by the propeller impulses. The outer wall is a covering shell, can therefore be provided at any points with maintenance panels etc. and is easy to produce, despite its double curved shape.

In the coleopter with ramjet and useful internal space, e.g. a supersonic fighter *(fig. 1c)*, the best solution would be a compromise.

However, still other solutions are possible, such as the design of the future shown in *fig. 1d*. Instead of having a covering shell, the outer form is made by filling up with a very light *foam substance*.[3] The latter completes the aerodynamic form and protects the sheets of the stressed shell, in this case particularly thin, and the thin, widely-spaced rings from local buckling. The tube is stabilized as a whole, and at the same time insulation is provided for the aerials (on the surface). The use of light foam substances, such as has been tried in the " sandwich " construction applied to conventional aircraft, is particularly promising in the coleopter, as here only a single-wall rotationally symmetrical shell has to be " foamed ".

The forward part of the annular wing can be used above all as tank space, as it is particularly suitable for tanks rendered leak-proof by either riveting or welding. The principle of such an annular tank is illustrated in *fig. 2*.[4]

Fig. 2 : Annular wing tank of a coleopter : The assembly process (a, b, c) is shown in longitudinal section.



Stress conditions on a single-wall stressed tube

Axial flow on to the annular wing, as well as pressures or negative pressures in the duct all produce *loads* on the stressed tube. A stream of air meeting the annular wing axially flows through and round it with rotational symmetry. These flows can be powerfully affected by rising temperatures in the combustion chamber of the ramjet engine. They cause radial positive or negative pressures on the walls *(fig. 3)* :

— with combustion chamber in operation : high positive pressure inside (ram ; action 1)

— with combustion chamber cold : high negative pressure inside (free internal flow ; action 2).

The value of these pressures (p) depends on altitude, speed, shape of duct and operating temperature. In supersonic flight at medium altitude (M = 2 to 2.5 at approx. 10 km), the inner positive pressure reaches roughly 1 to 2 kg/cm² when the combustion chamber is heated.

Radial pressures p are taken up by tangential normal stresses $\sigma = p \times r/s$, where r is the radius of the tube, and s its wall thickness. A light-metal tube with r = 150 cm and s = 0.15 cm can take up an internal positive pressure of p = 1.5 kg/cm², as σ = 1,500 kg/cm² is quite permissible. When the tube is of elektron, with a modulus of elasticity of E = 450,000 kg/cm², it expands considerably under this load. Radial expansion in all directions is $\Delta r = r\,\sigma/E$ = 0.5 cm. However, this would be acceptable if the movement were not hampered locally by the stiffening rings, thus forming ring-shaped corrugations (up to 5 mm deep when the rings are widely spaced).

The formation of harmful corrugations (aerodynamic disturbances, unequal strain on material) can be prevented as follows :

— by using a small number of very strong stiffening rings as widely spaced as possible, with the skin attached with sufficient play to enable the tube to expand unhampered over its whole length.

— by setting a larger number of weaker stiffening rings so closely together that they act sufficiently evenly over the whole length of the tube, thanks to the narrow spacing and a certain degree of " give ".

The following " rules of thumb " for combating the formation of corrugations have been obtained from detailed investigations :

— the disturbance caused by constriction reaches its maximum when the distance between the stiffening rings exceeds $3.2 \sqrt{s \times r}$;

— the distance between the rings should be reduced to about 50 % of this value.

There is thus no basic difficulty in providing for the absorption of internal positive pressure. However, the absorption of high external pressure presents more serious problems, as the stressed shell threatens to collapse under these stresses. This problem is attacked from two directions :

— *aerodynamically*, by preventing the occurrence of substantial negative pressure inside the duct when the ramjet is extinguished ;

— *statically*, by means of adequate stiffening.

*

Choice of materials : Where stability (and not strength) is the deciding factor, shells are made of the lightest possible materials, to reduce weight, ideally of magnesium alloys (elektron). Elektron sheets are 1.56 times as thick, 2.4 times as rigid (against bending) and 1.5 times as stable as duralumin sheets of the same weight,

and 4.4 times as thick, 18 times as rigid and 4.6 times as stable as steel sheets of the same weight, in all cases for stress from external pressures. The extra wall thickness also makes it possible to increase the distance between the stiffening rings. The use of elektron thus gives a substantial saving in weight, in the coleopter even more than in other configurations.

Critical external pressure : The critical external pressure of an isotropic, very thin-walled circular cylinder is in inverse proportion to the distance between the stiffening rings. A close spacing of the rings enables the thin tube wall to be stabilized as regards external pressure and at the same time an even deformation to be obtained in the case of internal pressures. *Small flying bodies* have a very good stability, and *medium-size machines* (such as interceptor fighters) can be brought to a considerable critical pressure. For *larger diameters*, up to about 10 m, a special structure with longitudinal members is under development.

The sole purpose of the closely spaced stiffening rings *(fig. 1)* is to provide local stabilization for the sheet. They receive a somewhat smaller tangential compression stress than the skin, and only minor additional bending stresses. To reduce the ring sections needed, it is of advantage to insert additional longitudinal members (bridges), not attached to the stressed shell, between the main rings in the case of large diameter tubes. The secondary rings are thus safeguarded against buckling and the second shell, reduced to the value of a covering sheet, is supported by the bridges. By concentrating the specifically lightest material in one stressed wall, it is possible to solve the problem of buckling stability with the minimum extra weight.

Incident flow with angle of attack, mass forces : If we regard the stressed tube as a rod attached to the central nacelle on one side by the radial arms, the diameter of this " rod " is very great in relation to its other dimensions. Cross section and I/y value [5] are so large, even when the walls are very thin, that the tube takes up the main stresses—shear, bending moment, longitudinal force—without difficulty. Forces are transferred to the support by sinusoidal shear flows distributed tangentially over the tube sections (cf. *fig. 3*). Here the local introduction and transference of the forces into this shear flow are most important.

Structural weight of the annular wing.

The static and structural advantages of the annular wing in conjunction with :

— rational design of the tube as a stressed body ;

— utilization of all favourable aerodynamic and static interactions when stiffening this thin-walled tube ;

— use of most suitable materials ;

— careful dimensioning

lead to very low unit weights (kg/m²). For *small* and *medium* diameters (D), unit weights (g) will be about $g = c_1 + c_2 D$. The constants c_1 and c_2 depend on the size of the loads and on the functions to be fulfilled by the wing (propeller duct or combustion chamber, fuel space or payload etc.).

It is readily understandable that the unit weight should depend on the diameter. Although unit weights continue to grow even for *large* diameters the use of the above formula would be too unfavourable in this case, and special studies have to be made for large aircraft.

For highly-stressed supersonic aircraft of medium diameter a unit weight of $2 + 3.5$ D is obtained, which gives a figure of 10 kg/m² for a diameter of 2.3 m. Thus the specific weights of annular wings in coleopter are substantially lower than those of conventional plane wings. The plane wing has 3 to 4 times the specific weight of the annular wing for the same task.

[5] I/y equals moment of inertia of the section about the control axis divided by the distance of the latter from the outermost fibre of the beam.

Although the unrolled area of an annular wing is 1.57 times its " lifting area ", the annular wing has a smaller structural weight than the plane wing of the same lifting area. According to statistical calculations the weight of the annular wing will be only about 40 % of that of the corresponding plane wing.

Comparison between annular-wing and plane-wing aircraft

Comparisons between the two kinds of aircraft should not be too general, but must be based on given tasks. Coleopters, which take off vertically, should therefore be compared only with vertical take-off plane-wing aircraft.

In favour of the coleopter are its low airframe weight and smaller power plant. The propeller duct formed by the annular wing increases static thrust by 25%. As engine size is determined only by take-off power, the coleopter power plant can be 20% lighter. Moreover airframe weight is reduced by about 25 % by the lighter wing.

Thus total weight empty is reduced by at least 25 % in favour of the useful load. Only a small proportion of this gain is taken up by the higher fuel consumption of the annular-wing aircraft of the same weight, so that even for long range there still remains about *10 % of the take-off weight as net gain in useful load.*

Short-range coleopters, in which fuel consumption plays a very minor role, can carry about twice as much payload—in relation to structural weight—as plane-wing aircraft.

The superiority of the coleopter becomes more marked, however, as range increases. Finally, the coleopter still has a payload at a range at which the payload of a vertical take-off plane-wing aircraft would sink to zero, i.e. at about 2,500 km. *This clearly demonstrates the superiority of the coleopter as a civil aircraft, especially for " medium " ranges.*

Jane's All the World's Aircraft 1954-55. Compiled and edited by Leonard Bridgman. Published by Sampson Low, Marston & Co., London, 1954. (English, 379 pages, price £4 4s. 0d.)

This new (45th) edition of the standard reference work enriches the earlier aircraft collection by a number of new types, which mark a great advance in development compared with the immediate post-war period. They include the North American F-100, Convair F-102, SFECMAS 1402 *Gerfaut*, and the Lockheed and Convair vertical risers, all based on material publicly available. The aircraft section contains many new photographs, and its data have been checked up to July 31st, 1954. In particular information on Russian aircraft has been expanded since last year, though, as usual, no speculative details are included. The four-jet long-range bomber first shown in public at the last Moscow May Day Parade is given among the " unidentified " types and illustrated by a three-view drawing. It is also stated that MiG-15 jet fighters are now being produced for the satellite air forces in all countries of the Eastern *bloc*. The Russian aircraft industry is said to comprise about 360 plants, 85 of which produce airframes and 30 power plant.

Re.

Im Spiel der Gewalten. — Novel by Ernest K. Gann, translated from the English by Lola Humm-Sernau (original title " The High and the Mighty "). — Published by Alfred Scherz, Berne, 1954 (German, 325 pages).

The author of this American best-seller, which ran into 14 editions in the United States within a short time, is a humanitarian, as well as being air-minded. Despite fire in the power plant, a leaky fuel tank, bad weather and miserable visibility, he manages to get his airliner, complete with crew and passengers, safely to San Francisco. The fears and anxieties of the flight make good reading. Firstly because Gann knows his trade and brings his story home to the reader in simple, not-too-technical, words, secondly because the team work of an airliner crew is described realistically and convincingly, and thirdly because the book never bores, but holds the reader's attention throughout.

He.

Abenteuer als Fallschirmjäger. — By Serge Vaculik. Translated from the French by Eduard Thorsch. (Original title " Béret Rouge "). — Published by Alfred Scherz, Berne, 1953 (German, 263 pages).

War experiences of a Czech living in France, who was taken prisoner by the Germans in 1940, escaped and joined the Free French Forces. Parachute training in England—jumping over Northern France—second capture and second escape. The book, awarded the " Prix Aviateur ", makes gripping reading. He.

Tourisme et Transports. — By Dr. J. G. Ramaker. Published by the Scientific Committee of the Alliance Internationale de Tourisme, Berne, 1954 (French, 102 pages).

This book analyses in brief, but graphic, form the influence of safety, speed, comfort, reliability and fares in various means of transport on the increase in travel in different countries. Air transport receives its fair share, especially among the photographs, which themselves form effective travel publicity.—However, the editor speaks of the tourist class in air transport only in the future tense, as if this service had not yet been introduced. This is a little out of date for the year—1954—of publication of the book, since tourist-class rates have been in operation throughout the world for eighteen months and have become a decisive factor in air transport. The results are regularly reported in *Interavia*.

He.

Jahrbuch der Luftfahrt 1954. — Edited by Karl Ferdinand Reuss for the German Aero Club. Published by Pohl & Co., Munich, 1954 (German, 328 pages, illustrations in the text).

Dr. K. F. Reuss, Vice-President of the German Aero Club and German delegate to the Fédération Aéronautique Internationale, has collected together in this handy pocket-size diary everything which the interested German should know about post-war development : aviation authorities, air transport, ground organization, industry, air law, sporting flying. A useful aid for all concerned with rebuilding German aviation.

He.

What's in the Air ? *

AVIATION POLITICS

• Ten years of I.C.A.O.

The tenth anniversary of the signature of the Chicago convention on civil aviation was celebrated in Montreal on December 7th, 1954. The convention, signed on December 7th, 1944, by more than 50 countries, is the charter of world air transport and the statute of the International Civil Aviation Organization, which today counts 65 member States. At the tenth anniversary celebrations the I.C.A.O. Council and its President Dr. Edward P. Warner recalled the most important principles of the Chicago convention. Henri Bouché, who has been France's representative on the Council since the creation of I.C.A.O., reminded his listeners of I.C.A.O.'s economic tasks, as laid down in the preamble and in Article 44 of the Chicago convention: *prevention of economic waste caused by unreasonable competition; equality of rights of contracting states and a fair opportunity for every contracting state to operate international airlines.* Bouché emphasized that as yet I.C.A.O. had achieved nothing in this field. However welcome I.C.A.O.'s successes had been in the introduction of common standards, joint action should be taken in order not to jeopardize what has already been achieved.

• The new Japanese cabinet

The list of ministers in the Hatoyama Government approved by Emperor Hirohito includes the following names of interest to aviation: Transport: Takeo Miki (formerly Post Office); Defence: Siichi Omura; Public Works: Yutaro Takayama.

SERVICE AVIATION

• New Chief of Dutch Air Force

Lieutenant General A. Baretta, hitherto Chief of Staff of the Royal Netherlands Air Force, has been appointed Commander-in-Chief. The latter post had been vacant since the retirement of Lieutenant General Izaak A. Aler, now President of K.L.M.

• U.S. armed forces strength

Strength of the United States armed forces at the end of October 1954 was 3,257,266 officers and enlisted men, including 1,370,285 in the Army, 963,500 in the Air Force, 702,129 in the Navy and 221 352 in the Marine Corps, the U.S. Defense Department announces. — A reduction to 3,047,000 is planned by June 30th, 1955.

• B-47 wing's Florida-North Africa flight

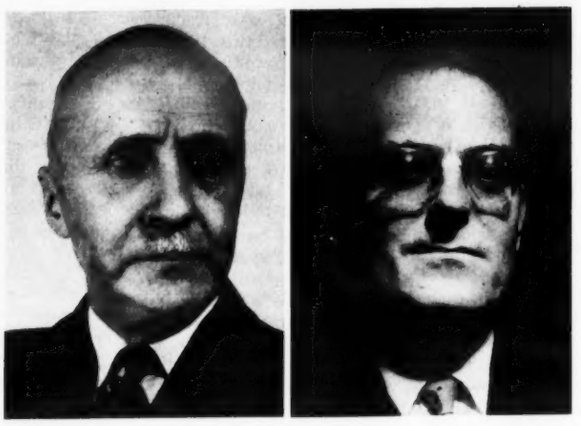
United States Air Force Headquarters in Washington announce that a wing of Boeing B–47 jet bombers is to fly non-stop from Tampa, Florida, to North Africa during January for a 45-day period of "global mobility" training. The wing, the 306th of Strategic Air Command, based at MacDill AFB, will be refuelled in flight by Boeing KC–97 tankers of the 305th Squadron, also stationed at MacDill.

AIR TRANSPORTATION

• Stiffening of competition in world air transport

Reports on the atmosphere prevailing at the I.A.T.A. Traffic Conferences in Venice (October 1954) show that there was considerable difference of opinion among I.A.T.A. member companies on the fares and rates to be introduced in April 1955. Just as the question of Atlantic cargo rates was left unresolved at the I.A.T.A. Tenth Annual General Meeting in Paris, numerous individual tariffs also remained undecided at the Venice conference. *From the spring of 1955 I.A.T.A. will have no more control over fares on a number of important long-distance routes in all three traffic regions* (for example, Far East–United States–Great Britain). — These reports from Venice have now been supplemented by information that a number of South American airlines are thinking of withdrawing from the International Air Transport Association. The reason given is that because of their obsolescent equipment they can only compete with other companies if they underbid the I.A.T.A. rates.

Federal Councillor *Dr. Joseph Escher,* head of the Swiss Postal and Railway Department, died of a heart attack during a Parliamentary session on December 9th. The new Swiss Air Law entered into force during Dr. Escher's period of office.



New Swiss Ministers: Newly-elected *Federal Councillor Dr. Thomas Holenstein* (left) has taken over the Postal and Railways Department, in succession to the late Dr. Escher. — The Military Department is now headed by *Federal Councillor Giuseppe Lepori* (right), in succession to Federal Councillor Kobelt, who has retired.

• Airport expansion throughout the world

French Union: The new installations at Algiers-Maison Blanche Airport, including a concrete runway 7,970 ft. long and 200 ft. wide, are to be ready for operation by June 1955.

Italy: The Italian Cabinet has approved the continuation of the work on *Rome-Fiumicino* Airport.

J. V. Naish, Executive Vice-President of *Convair* (seated) and *H. Sammons,* Managing Director of *D. Napier & Son Ltd.,* London, signing the agreement under which Napier has purchased a Convair 340 for experimental fitting with Napier *Eland* propeller turbines.

United States: Hyatt House, the new airport hotel at Los Angeles airport, has been opened. Builder Hyatt Robert von Dehn is confident that transit air travellers will keep his $ 1,500,000 "prototype" airport hotel well filled. He plans to build other Hyatt Houses in the United States, at San Francisco, New York, Denver, Houston, Phoenix, Chicago, Honolulu, and in Europe, at Paris, Rome, Madrid.

Japan: The new passenger building at *Tokyo-Haneda* airport is to be finished by May 1955. The remaining installations are also to be extended, with the main runway being increased to 8,370 ft.

• Business aircraft in the United States

According to figures published by the Aircraft Industries Association, approximately 21,500 executive aircraft are now in service with business firms in the United States. Of these 2,437 are multi-engined types, and 19,063 single-engined types. This total is nearly seven times the total fleet of all American domestic airlines. In 1953 executive aircraft covered a total of 903,000,000 miles, while U.S. domestic airlines flew only 525,164,916 miles.

• Indian Air Force and air transport

Air-India International and *Indian Airlines Corp.,* the two Indian Government airlines created on August 1st, 1953 by the amalgamation and nationalization of almost all private companies, have been struggling with manifold difficulties for many months. Indian Airlines, which operates the domestic services, has shown disquieting deficits and — like Air-India International — faces the constant threat of serious labour disputes. — Air Marshal S. Mukerjee, Chief of the Indian Air Staff, has now been appointed to the Board of Directors of both companies. Indian aviation circles believe this appointment will improve the situation, since Mukerjee has the specialist experience lacking in other Board members — with the exception of J.R.D. Tata, its Chairman.

INDUSTRY

• Honour for Professor Theodore von Karman

The Institute of the Aeronautical Sciences (I.A.S.) has awarded *Professor Th. von Karman* the "*Wright Brothers Memorial Trophy*". The

* Extracts from *Interavia Air Letter,* daily international news digest, in English, French and German. All rights reserved.

official presentation was made in Washington at the 18th Wright Brothers Lecture.

• Canadian aircraft exports

During the first half of 1954 Canada exported aircraft and aircraft parts to the value of $ 17,860,331. The Canadian authorities expect that total exports for the year will equal those for 1953 ($ 40,000,000). The figure does not cover Canadian deliveries under the Mutual Aid Programme. — Of the 131 aircraft exported during the first half of 1954 no fewer than 118 went to the United States (value $ 7,178,056). The remaining 13 were distributed among the following countries : Norway 7, New Zealand 2, Yugoslavia 2, Colombia 1, French Indo-China 1.

• Reorganization of Hawker-Siddeley Canada

A.V. Roe (Canada) Ltd., Canadian member of the Hawker Siddeley Group, is to have three subsidiary companies : *Avro Aircraft Ltd.* (aircraft manufacture ; 10,000 workers ; Manager Fred T. Smye) ; *Orenda Engines Ltd.* (engine production ; 6,000 workers ; Manager W. R. McLachlan) ; *Canadian Steel Improvement Ltd.* (precision forgings and alloys ; 400 workers ; Manager C.J. Luby). — Sir Roy Dobson, Managing Director of A.V. Roe and Co. Ltd., one of the Group's main companies, will be Chairman of the Dominion Group. According to Avro-Canada's President Crawford Gordon, the reorganization has developed as a result of the rate of growth and increasing complexity of the aircraft industry in Canada. The point has been reached, for instance, where airframes and aero engines have to be dealt with independently. Each of the three operating companies will be free to develop its own products and cater to its own customers. — Avro-Canada also plans to branch out into the armament and electronics fields, according to *Interavia's* Toronto correspondent. At the present moment, all radar equipment and sights for the CF-100 *Canuck* fighter have to be imported from the United States, at a cost of more than $ 200,000.

• American-European licence agreements

Interavia's Los Angeles correspondent expects that U.S. State Department rules on the licence-production of American aircraft and equipment in other friendly countries will shortly be relaxed, and that trade tie-ups with other nations may soon reach multi-million dollar proportions. — Approval has recently been given for a licencing agreement between AiResearch Manufacturing Co., Los Angeles (a subsidiary of The Garrett Corp.) and the British firm of Normalair Ltd. covering the production of refrigeration turbines and pneumatic controls. AiResearch has also licenced Rotol Ltd. to manufacture air turbine motors and ram air turbines.

• Honour for German air law expert

To mark the 75th birthday of Prof. Alex Meyer, head of the Air Law Research Section at Cologne University, the North Rhine-Westphalia Ministry of Economy and Transport has issued a commemorative booklet containing contributions by well-known air law experts throughout the world. — Prof. Meyer is known chiefly for his basic work on " Freedom of the Air as a Problem of Law ", published in 1944.

Flying Equipment

• Bristols have fixed a target of mid-1955 for certification of the *Britannia* turboprop airliner.

• The Short *Seamew*, normally employed as a carrier-based anti-submarine aircraft, can also be used for the following purposes : coastal patrol, communications services, artillery observation and reconnaissance, the makers state.

Charles T. Zaoral, hitherto Director, Operations to *New York Air Brake Co.*, has been appointed President of the company.

Foreign visitors to English Electric : A delegation from the Peruvian Air Force, led by General Enrique Bernales, the Peruvian Air Minister, has visited the English Electric plant at Warton, Lancashire, where it watched a demonstration flight by a *Canberra*. Left to right : Major Fossa (Deputy Chief of the Peruvian Air Staff), Mr. Hobday, Wing Commander Milne, Air Commodore Graham (all of English Electric), General Enrique Bernales, Colonel Moya (Commander-in-Chief of the Peruvian Air Force).

• Growing interest in light helicopters for use by the British Army has repeatedly been referred to in these pages. Sir Richard Fairey has now stated that his company has been awarded a contract for an *ultra-light helicopter* to meet Army requirements, and possibly later for N.A.T.O. — A second prototype of the *Rotodyne* with modified internal equipment has also been ordered from Fairey.

• Water tank pressure tests are to be made on the *Handley Page Herald* feeder airliner. *Aviation Traders* are also negotiating with the Royal Aircraft Establishment, Farnborough for tests on their *Accountant* in the latter's water tank.

François de la Brosse, head of Air France's foreign service, proved himself to be a capable organizer during the preparations for and the course of the Tenth I.A.T.A. Annual General Meeting.

• The prototype of the bomber version, SO.4050-03, of the SNCA du Sud-Ouest *SO.4050 Vautour* began flight testing at Melun-Villaroche on December 5th, 1954, piloted by Test Pilot Ch. Goujon.

• The *Nord 2600* project worked out by *SNCA du Nord* under a development programme for twin-engined turboprop commercial transports is fitted with two *Dart* propeller turbines and two *Palas* auxiliary turbojets at the wing tips. — Span 95 ft. 1¾ ins., length 66 ft. 5¼ ins., gross weight 37,480 lbs., cruising speed 295 m.p.h. at 19,680 ft. — The Nord 2,600 is a rival design to the Hurel-Dubois HD.70.

• The first of a series of special *Convair C-131B* aircraft ordered by the U.S. Air Force for flight testing electronic equipment made its first flight in San Diego at the end of 1954. — A second *Convair YC-131C* turboprop transport (Allison T-56) has also begun flight testing.

• *Boeing 707* wing-tip ailerons are locked into neutral position when the undercarriage is retracted. Except during take-off and landing, all wing control is relegated to spoilers and negligibly small mid-span ailerons, situated between the wing's outboard and inboard landing flaps.

• The U.S. Air Materiel Command is testing a number of probe and drogue systems of *refuelling fighters in the air*, two of which have been developed by Fletcher Aviation Corp. One of these systems is known as the Para-Drogue System, and uses a small parachute to stabilize the trailing drogue.

• Power Plant

• The *Dart propeller turbine* will probably be built for several years yet. The *Dart Mark 510* version of 1,550 h.p. max. power will be in production by June 1955, and a further development of roughly 1,800 h.p. is planned.

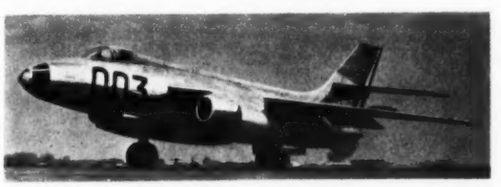
• New engine designations : *Avon RA.18*, *Conway RCo.5*. — Thrust of the *Soar RSr.1* has been measured on the test bench as 1,760 lbs.

• Armstrong Siddeley announces conclusion of a 150-hour test run on the *Sapphire 7* turbojet ; thrust measured 10,200 lbs, without use of thrust-augmenting devices, such as water injection, reheat etc.

• Curtiss-Wright plans to market a civil version of the *T-49 propeller turbine*. This engine normally delivers about 10,000 h.p., though the civil version will have a lower power.

• General Electric announces quantity production of a new version of the J-47 turbojet, the *J-47-GE-33*. — To be used in the F-86D and K.

SO.4050-03 bomber version of SNCA du Sud-Ouest's *SO.4050 Vautour*.



S. N. C. A. du Sud-Est workshop : correction

In the December issue of *Interavia* a picture of a Dassault jet fighter production line was used to illustrate the article " U.S. Senators Inspect European Arms Plant ". The workshop shown is not, as stated erroneously in the caption, at the Dassault plant, but at *S.N.C.A. du Sud-Est's Toulouse factory*. The Editors apologize for this error.

Photo credits : Front cover : Interavia ; pp. 20-21 : Lieselotte Thommes-Kober (1), Interavia drawing (1) ; pp. 22-23 : author ; pp. 24-25 : " La Guerre Infernale " (3), " Vingtième Siècle " (2), " Aéronaute " (2), " Je Sais Tout " (1) ; p. 26 : manufacturers ; pp. 27-28 : manufacturers (12), Interavia records (3) ; pp. 29-34 : author ; pp. 35-38 : author ; pp. 39-41 : ATP (1), manufacturers (5), Interavia records (1) ; pp. 42-43 : Interavia ; pp. 44-45 : author (2), Interavia records (1) ; pp. 46-47 : Interavia drawing (1), Interavia records (2) ; p. 47 : " Daily Mail " ; pp. 48-60 : manufacturers ; pp. 51-53 : author ; pp. 53-55 : author ; pp. 56-57 : ATP (2), Air France (1), manufacturers (3), Interavia records (2).

THE FOUGA 170 R Magister

IS EQUIPPED BY:

L'ÉQUIPEMENT ET LA CONSTRUCTION ÉLECTRIQUE

Tout l'appareillage électrique de commande, de signalisation, d'interruption, de protection.

Servo-mécanismes

Tél. : MEN. 20-10 — 17, rue Pelleport PARIS XX^e

SOCIÉTÉ D'ÉQUIPEMENT RADIO AÉRONAUTIQUE

Installations électroniques de bord et d'infrastructure

75, RUE CLAUDE-BERNARD
Tél. : GOB. 10-70 et 10-71

PARIS V^e

ETS A.M.A.

1, Boulevard Bineau
Levallois (Seine)

JAUGEURS
Contrôle Moteur
Filtres
Circulation d'huile
Radiateurs

Equipement hydraulique
Poignées de pilotage
Micro-rupteurs
Réarmement hydraulique

S.A.M.M.

12, rue Jules Brégère
BOULOGNE-BILLANCOURT
Téléphone : MOL. 73-76

Ecrous de sécurité

«NYLSTOP»

SIMMONDS S.A.

7, rue Henri Barbusse LEVALLOIS (Seine)

MATRA

LANCE-ROQUETTES

49, rue de Lisbonne PARIS

Kléber-Colombes

PNEUS
et
JOINTS de COCKPIT

See also

SOURIAU
AVIATION

SOCIÉTÉ D'OPTIQUE, DE MÉCANIQUE, D'ÉLECTRICITÉ ET DE RADIO
O.M.E.R.A.
ÉQUIPEMENTS ÉLECTRONIQUES
OPTIQUE ET MÉCANIQUE DE PRÉCISION
Emetteurs-récepteurs de bord - V.H.F. SARAM - 5-52
Enregistreurs cinématographiques de visée SEPHOT Type 20
Appareils photographiques SEPHOT - Type 10 et Type 11
49, rue Ferdinand Berthoud, Argenteuil (S.-&-O.) - TÉL. 04-68 et 18-88

JAEGER
ALTIMÈTRES - TACHYMÈTRES
ACCÉLÉROMÈTRES
FICHES MULTIBROCHES

LE BOZEC & GAUTIER
28, rue Carle-Hébert - COURBEVOIE
équipe la circulation du combustible du
FOUGA - CM 170 R
Marque L.B déposée

S^te GÉNÉRALE D'EQUIPEMENTS
40, Quai National - PUTEAUX

TOUTE L'INSTALLATION ÉLECTRIQUE ET ÉLECTROMÉCANIQUE
• CANALISATIONS et TABLEAUX PRÉFABRIQUÉS
• APPAREILLAGES
• ÉCLAIRAGE INTÉRIEUR et EXTÉRIEUR
• ÉLECTROMÉCANISMES Licence LEAR
DU **CM. 170**

VALLOUREC
TUBES EN ACIERS SPÉCIAUX SANS SOUDURE ET SOUDÉS
— Au chrome-molybdène et nickel-chrome pour constructions soudées et trains d'atterrissage
— Inoxydables
— Résistant aux hautes températures
— Pour roulements
BOUTEILLES
— Légères pour gaz comprimés
— Inhalateurs
— Extincteurs

SFENA
SOCIÉTÉ FRANÇAISE D'ÉQUIPEMENTS POUR LA NAVIGATION AÉRIENNE
25-29, rue du Pont — Neuilly (Seine)
DÉPARTEMENT ÉQUIPEMENTS
Horizons gyroscopiques
Gyroscopes directionnels
Gyromètres
Compas magnétiques
Pilotages automatiques
Commandes d'engins spéciaux
Moteurs d'asservissement de 10 à 100 watts
DÉPARTEMENT ÉLECTRONIQUE
Télécommandes et téléindications
Emetteur-récepteur de liaison V.H.F. léger de trafic
Mesureur de champ
Auto-directeur

MESSIER
Atterrisseurs - Roues - Freins et Equipement hydraulique pour les prototypes 01, 02, 03 et la série
58, RUE FENELON - MONTROUGE (SEINE). TEL. ALE. 22-36

following pages

THE FOUGA 170 R Magister IS EQUIPPED BY :

SUR Magister
CONDITIONNEMENT D'AIR
SEMCA
- TURBO-REFRIGERATEUR • REGULATEUR DE PRESSION • ROBINETS •
- VANNES • CLAPETS • RACCORDS.

Etablissements H.B.
TUYAUTERIES AVIATION
pour tous fluides
pour toutes pressions
avec tous raccords
JOINTS ET PROFILÉS CAOUTCHOUC
pour hautes et basses températures
30, Rue du Capitaine Ferber, MIC. 18-01
Issy-les-Moulineaux (Seine)

BRONZAVIA
207 BOULEVARD SAINT DENIS COURBEVOIE SEINE
EQUIPEMENTS AERONAUTIQUES
ÉQUIPEMENTS RADIO
CHAUDRONNERIE POUR L'AVIATION (MOTEURS ET RÉACTEURS)
MÉCANIQUE GÉNÉRALE
ÉQUIPEMENTS ÉLECTRO-MÉCANIQUES
ALIMENTATION DES MOTEURS ET DES RÉACTEURS
OPTIQUE ET MÉCANIQUE DE PRÉCISION
PRESSURISATION ET CONDITIONNEMENT DE CABINES

ULMER
- MASQUES INHALATEURS D'OXYGÈNE
- CHENILLES SOUPLES ARMÉES POUR OXYGÈNE
- PROJECTEURS FIXES ET ESCAMOTABLES D'ATTERRISSAGE
- PROJECTEURS DE ROULAGE
- MATÉRIELS HAUTE-FRÉQUENCE

67, Boulevard BESSIÈRES
PARIS XVII^e
MARcadet 16-09 - 50-8[illegible]

R. ALKAN & Cie
Matériel d'Armement pour Avions
Matériel de navigation
50, av. Claude Vellefaux, Paris 10^e
Tél. : Bot. 89-10 et Nor. 74-04

S.E.C.A.N.
SECAN
40 RUE H. BARBUSSE - GENNEVILLIERS - GRE - 58.20

THE Ni-Cd AIRCRAFT BATTERY
HIGH OUTPUT
HERMETICALLY SEALED
NO MAINTENANCE
Pont de la Folie
ROMAINVILLE (Seine)
VOLTS FABLO[illegible]

See also

CELLOLAC

TOUTES PEINTURES
ENDUITS - VERNIS

*

49, avenue du Vésinet
CROISSY-SUR-SEINE
SEINE-ET-OISE
PRINCESSE : 20-92 — 26-50

LES APPLICATIONS DU ROULEMENT

CHAMPIGNY THOMERY
FONDÉ EN 1925

Roulements pour commandes de vol
Demander le catalogue « AIR 54 »

Roq 09 68 **PARIS XI^e** 2, r. Bréguet

DYNAMOS DE TOUTES PUISSANCES
REGULATEURS DE TENSION
CONJONCTEURS - DISJONCTEURS
RELAIS-INTERRUPTEURS-INVERSEURS
CABLAGES PRÉFABRIQUÉS, etc...

LABINAL

126, Bd Victor-Hugo, SAINT-OUEN (Seine) - CLI. 57-36

SUPERFLEXIT

2, RUE DU PARC - **BOIS COLOMBES** (SEINE)
TÉLÉPH. **CHARLEBOURG** 45-17

RÉSERVOIRS SOUPLES
et protections de réservoirs increvables et ininflammables.

TUYAUTERIES SOUPLES
pour essence, huiles et tous les hydrocarbures.

Commandes mécaniques à distance
par la crémaillère souple

TELEFLEX

Département de **Tiss-Metal,** Lionel Dupont & Cie
130, Avenue Jean Jaurès, Ivry-sur-Seine
Italie 45-87

COMPAGNIE FRANÇAISE DES MÉTAUX

Société Anonyme au Capital de 2.487.500.000 frs.

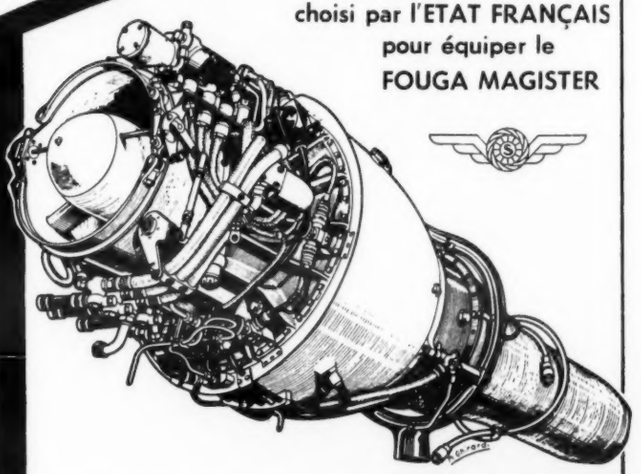
TOUS LES MÉTAUX

Demi-produits en aluminium et alliages d'aluminium

7, Rue du Cirque, Paris 8^e - Tél. : Elysées 29-80

LE "MARBORÉ"

choisi par l'ETAT FRANÇAIS
pour équiper le
FOUGA MAGISTER



est utilisé par **5 NATIONS SUR 14 TYPES D'AVIONS**
Est construit en série en **FRANCE**, et sous licence :
aux U. S. A. (2 versions pour l'U.S. Air Force)
en GRANDE-BRETAGNE et en ESPAGNE

TURBOMECA
BORDES (Basses Pyrénées)

La mise au point
DU CM 170 R MAGISTER
a été réalisée grâce au matériel
pour essais
en vol

SFIM

140 rue Lafayette PARIS - Combat 63-09

preceding pages

COLEOPTERS

DESIGN

of civil and military aircraft of COLEOPTER configuration and of guided missiles of similar type.

SALE OF LICENCE RIGHTS

to patents covering aircraft, flying bodies, power plants and landing methods

AERONAUTICAL ENGINEERING CONSULTANTS

BUREAU · TECHNIQUE · ZBOROWSKI

1, Avenue d'Orléans, Brunoy, Seine-et-Oise, FRANCE

Temporarily: Château de Boussy, Saint-Antoine, par Brunoy, S.-et-O., FRANCE

Telephone: Brunoy 50 Cables: BETEZET – Brunoy

ASIA
EUROPE
AFRICA
U. S. A.

AUSTRIA — EGYPT — FRANCE — GERMANY
GREECE — IRAN — IRELAND — ISRAEL — SPAIN
SWITZERLAND — TUNISIA — TURKEY
UNITED STATES
connected with the whole Italian network
by **DOUGLAS DC-6B**
and **CONVAIR LINER**

LAI

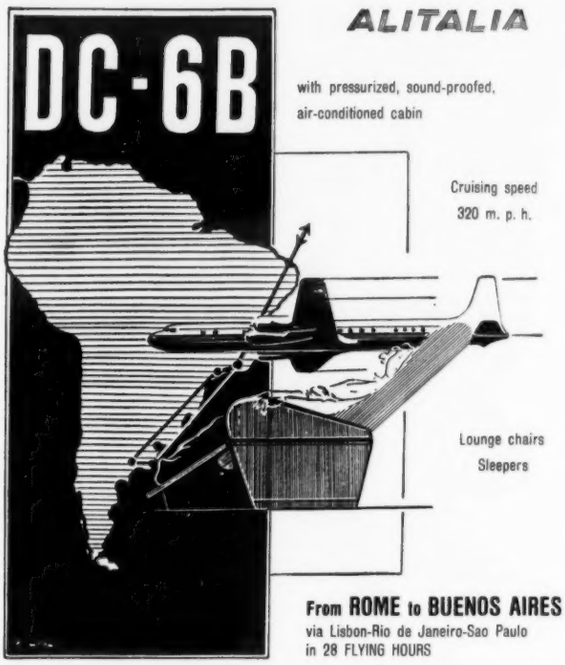
LINEE AEREE ITALIANE
in Switzerland : SWISSAIR

By

ALITALIA

DC-6B

with pressurized, sound-proofed, air-conditioned cabin



Cruising speed
320 m. p. h.

Lounge chairs
Sleepers

From ROME to BUENOS AIRES
via Lisbon-Rio de Janeiro-Sao Paulo
in 28 FLYING HOURS

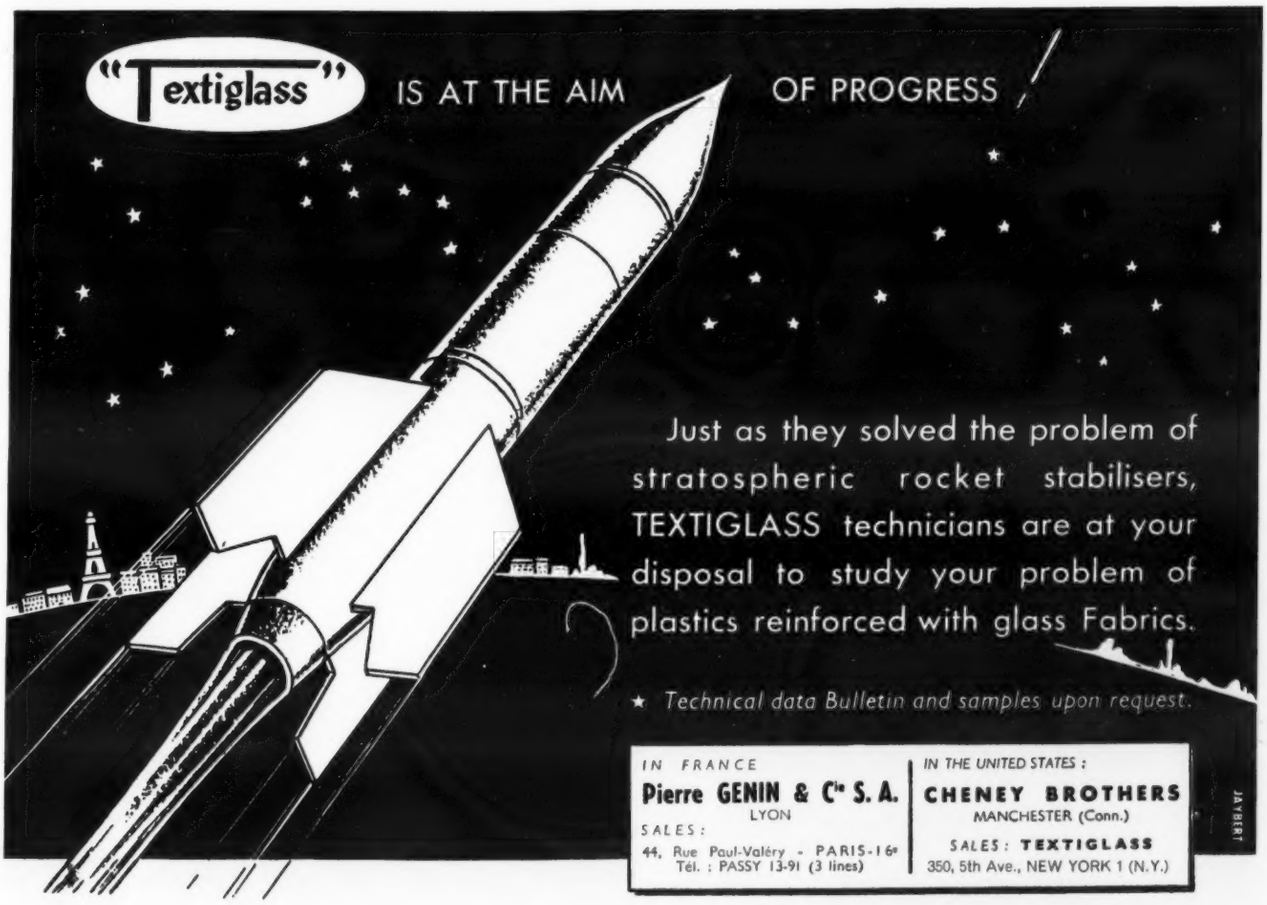
Information and reservations from your own travel agency
or from :

ALITALIA

ROME : 15, Via L. Bissolati
Tel. 470.242

MILAN : 6, Via G. Verdi
Tel. 877.107

"Textiglass" IS AT THE AIM OF PROGRESS



Just as they solved the problem of stratospheric rocket stabilisers, TEXTIGLASS technicians are at your disposal to study your problem of plastics reinforced with glass Fabrics.

★ *Technical data Bulletin and samples upon request.*

IN FRANCE
Pierre GENIN & C^ie S. A.
LYON
SALES :
44, Rue Paul-Valéry - PARIS-16^e
Tél. : PASSY 13-91 (3 lines)

IN THE UNITED STATES :
CHENEY BROTHERS
MANCHESTER (Conn.)
SALES : **TEXTIGLASS**
350, 5th Ave., NEW YORK 1 (N.Y.)

JAYBERT

OFFICINE DI POMIGLIANO PER COSTRUZIONI AERONAUTICHE E FERROVIARIE

Aeronautical production: aircraft and parts

AERFER

PRODUCTION PLANT AT POMIGLIANO D'ARCO

OFFICES IN NAPLES, CORSO UMBERTO 1°, 22

ACCENT ON ACCURACY

During every stage of repair and inspection of aircraft components, engines, accessories and instruments, highest accuracy is maintained as a standard practice in KLM's Technical Division. For that reason the instrument shop (see picture) where every type of precision-made flight instrument is examined, is scrupulously clean, air-conditioned, humidity controlled and dustproof. Tests are automatically controlled by recording instruments and diagrams supplied with each overhaul, and many an item of the high-speed equipment operates with the extra benefit of being improved by KLM's own engineers.

For a thorough, C.A.A. approved job, contact

KLM's TECHNICAL DIVISION
SCHIPHOL AIRPORT

Amsterdam — Holland

KLM
ROYAL DUTCH AIRLINES

fm

The Milan Fair brings you right up to date with the most recent developments and latest novelties of international production. It freshens the ideas. It provides new and useful contacts. It stimulates the turnover of the business world.

Italy awaits you in April for the

33rd Milan Samples Fair

An unrivalled display of world production

In 1954: 12.336 exhibiting firms
50 participating Nations
90 different sections
4,110,000 visitors
buyers from 109 Countries

The General Secretariat of the Milan Fair, the Honorary Delegations of the Fair abroad and the Italian diplomatic and consular Representatives will be pleased to provide you with illustrative material, advice and assistance.

12th - 27th April 1955

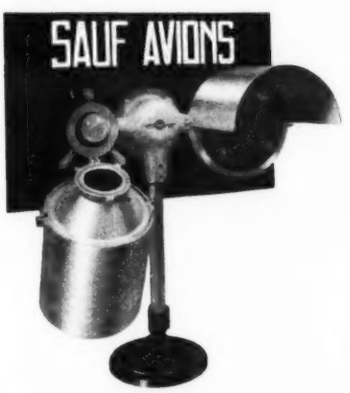
VANYPECO

TRAFFIC
on Airports

The specialized firm of A.D.B. has just perfected a new apparatus designed to increase the safety of traffic on airports.

The equipment—illustrated here—is designed to signal to aircraft taxying on the ground and to all vehicles moving on the runways. The red and green lights are remote-controlled from a special desk.

The illustration below shows the adaptability of the equipment. It is also fitted, as a safety measure, with a breaking unit at its base, which can be exchanged in an instant.



A.D.B. Air Equipment is once again in the forefront of progress. The list of its achievements lengthens day by day : 8 N.A.T.O. airfields, Brussels-National, Brussels G. Stanleyville, Caselle-Turin, Bagdad West Airport.

A D B

ADB AIR EQUIPMENT S. A.

SURVEYS — ESTIMATES
60, RUE FERNAND-SÉVERIN
BRUSSELS, BELGIUM

HIGH AND LOW INTENSITY RUNWAY LIGHTS, TAXI-LIGHTS AND APPROACH LIGHTS — CONSTANT CURRENT REGULATORS FOR SERIES SYSTEMS — ILLUMINATED WIND TEES — CONTROL DESKS — OBSTRUCTION AND HAZARD LIGHTS — RADIO-CONTROLLED BRIGHTNESS OF RUNWAY LIGHTS FROM THE PLANE.

POTEZ 75

GROUND SUPPORT AIRCRAFT

450 H. P. POTEZ 8 D ENGINE

SOCIÉTÉ DES AVIONS ET MOTEURS HENRY POTEZ

Kléber 27-83 — 46, avenue Kléber, PARIS XVI[e] — POTEZAERO-PARIS

Jacks
Hoists
Scaffolding
Lifting Trolleys
Slings
Light cranes
Loading Platforms

Access
Hoisting
Handling
Shelter

AÉRO-SERVITUDES

GENERAL DESIGN AND PROJECTS DESIGN AND CONSTRUCTION of all STANDARD AND SPECIAL equipment required for aircraft servicing

E TN

SERVICE INTER

ÉTUDES et TECHNIQUES NOUVELLES, 5, Rue Jean-Mermoz, PARIS-8[e], ELY.-53-50

Wanted exclusive sales rights for aircraft and aeronautical equipment

INTRACO
G. m. b. H.

MUNICH 15 - Landwehrstrasse 3
Telephone 55 4 77
Teleprinter 052/3310

"In the Service of Air Ballistics"

S.E.P.R.

(Sté d'ÉTUDE de la PROPULSION par RÉACTION)

designs — builds — flies

"THE ROCKET"

in all its applications

Head office : 37, Rue des Acacias, PARIS (17[e])

Bindings

for the 1954 volume of

Interavia Review

blue imitation leather with gold lettering for home binding

Order from INTERAVIA's nearest representative or distributing agent, or from your bookseller

Price : $2.60 / 18 shillings / 11. — Swiss Francs } including postage

SERVICES LINKING

4 continents

Printed in Switzerland

Bendix International in Aviation

The part of Bendix in the technical progress of aviation is vast and varied. Because Bendix has always anticipated aviation's next advance, every plane that flies, in some way, relies on Bendix Creative Engineering.

Bendix weather instruments provide the vital data for flight plans. Bendix filters guard the fuel used by engines equipped with Bendix starters, generators, ignition and fuel systems.

Bendix automatic pilots, instruments, radio, actuating mechanisms, and other scientific devices surround planes with safety and guide them to port.

Bendix is first in fuel metering systems for jets, ram jets and turbo-prop engines—a leader in landing gear—the world's largest producer of Aviation Instruments and Accessories—the standard of major airlines in radio and other electronic equipment.

When you see the name "Bendix Aviation Corporation" on any product, you can buy that product with complete assurance that it is the final word in creative engineering and the last word in quality.

Bendix International
Division of
Bendix Aviation Corporation
205 East 42nd Street,
New York 17, N.Y., U.S.A.
Cable "Bendixint" N.Y.

Bendix INTERNATIONAL Products

TRADE NAMES OF AMERICA'S FOREMOST FAMILY OF AVIATION PRODUCTS

Bendix · Eclipse · Pioneer · Skinner
Stromberg · Friez · Pacific

the man from Esso...

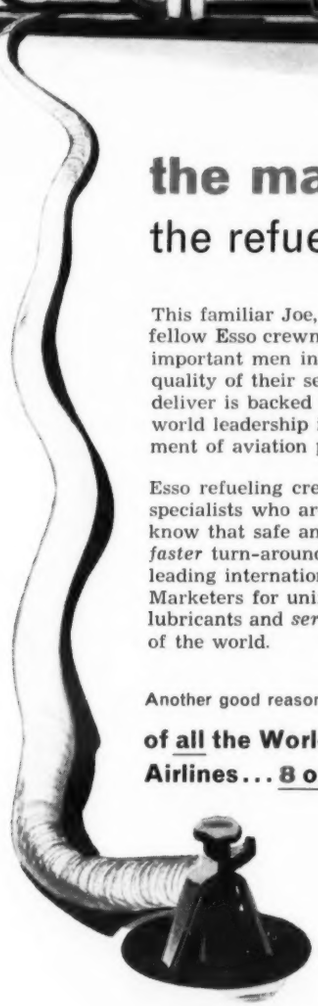
the refueling crewman

This familiar Joe, Jose or Giovanni and his fellow Esso crewmen around the world are important men in the aviation industry. The quality of their services and of the products they deliver is backed by more than half a century of world leadership in the research and development of aviation petroleum products.

Esso refueling crewmembers are trained specialists who are proud of their jobs. They know that safe and efficient servicing means *faster* turn-around for aircraft. Operators of leading international airlines rely on Esso Marketers for uniform high quality of fuels, lubricants and *service* along the airways of the world.

Another good reason why:

of all the World's International Airlines... 8 out of 10 use



Esso

AVIATION PRODUCTS